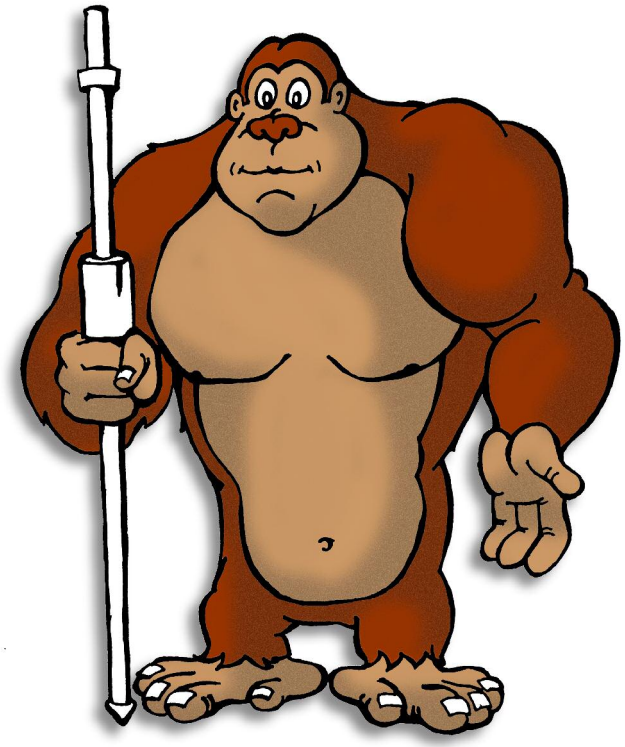
Headquarters U.S. Air Force

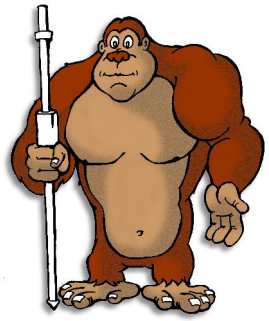
Integrity - Service - Excellence



Contingency Airfield Pavement Evaluation

Richard B. Smith

HQ AFCESA/CESC

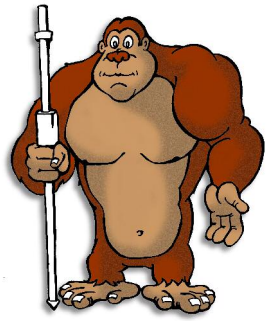


Airfield Evaluation Classifications

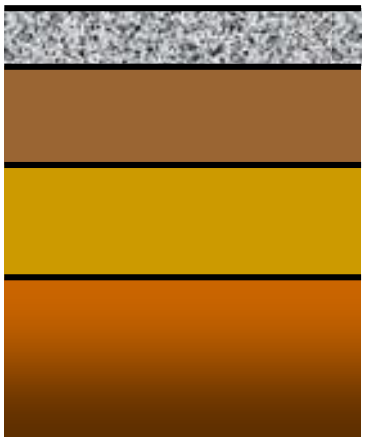
- Expedient (100 passes or initial surge of mission aircraft)
- Sustainment (5,000 passes or throughout anticipated operation)
- Permanent (≥ 50,000 passes or long term operations)

- All require same basic procedures, but differ in amount of data used in the evaluation and in turn the reliability of the results, as well as the detail in the report.

- Classification of evaluation is driven by the mission and time allotted for field work and analysis.



Simpleton Airfield
Typical Cross Section

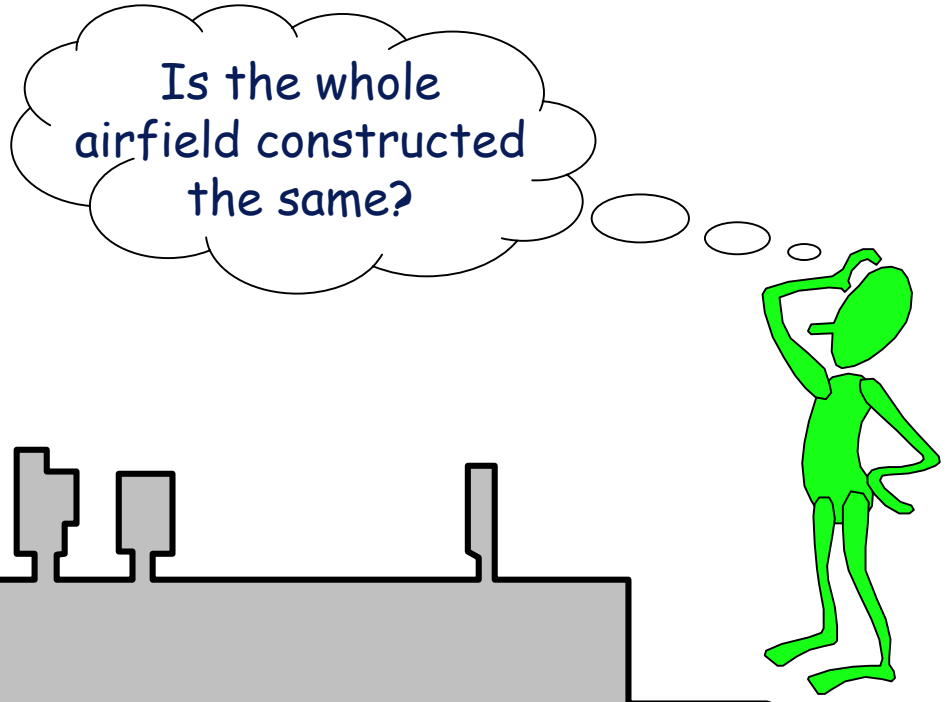


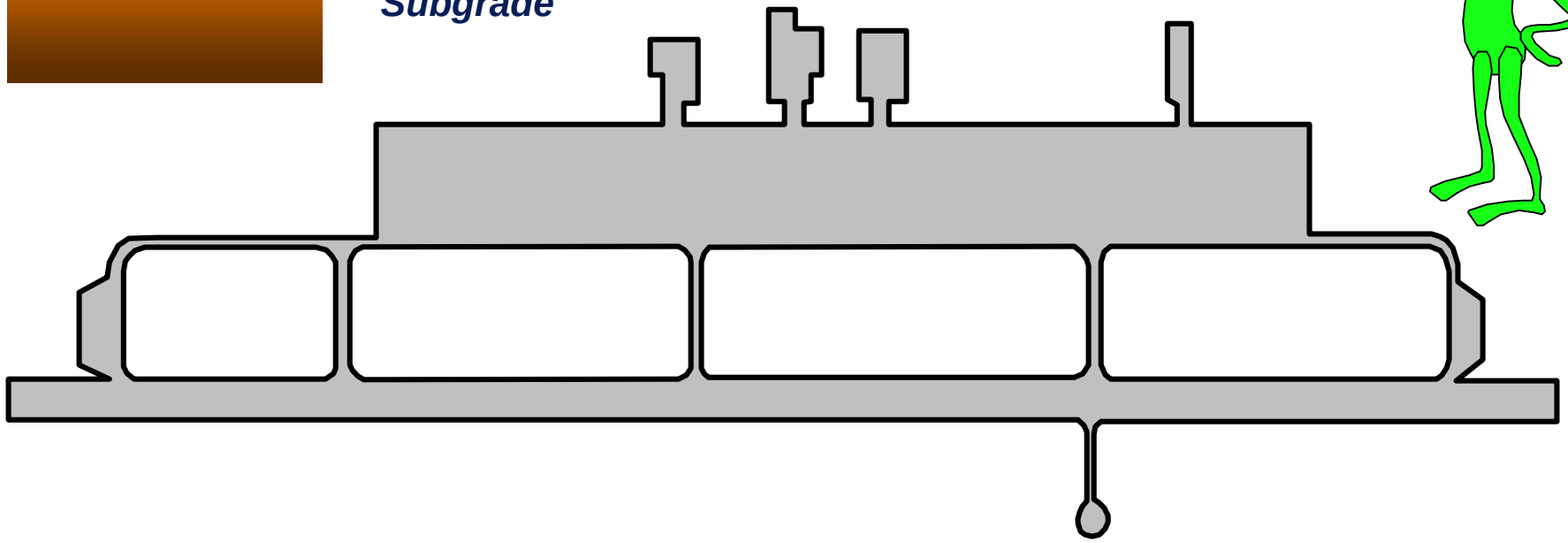
6” AC

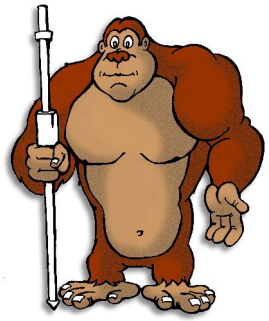
12” Base Course

12” Subbase Course

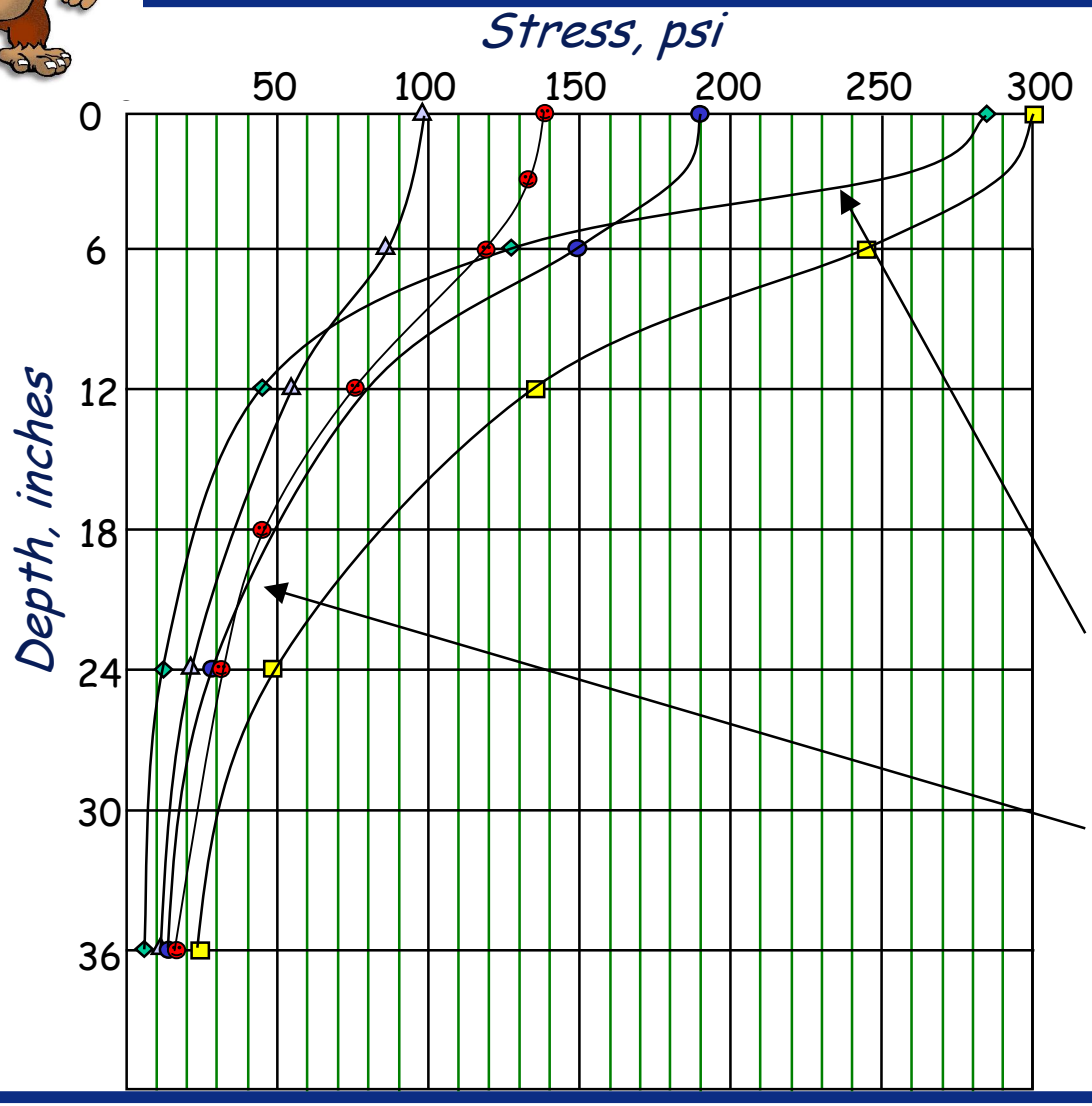
Subgrade







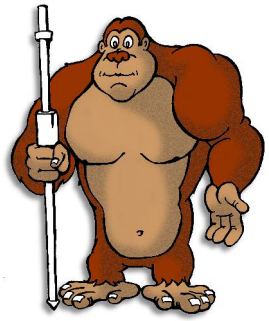
Do all aircraft have the same impact on pavement ?



Stress with Depth
Single Wheel Load

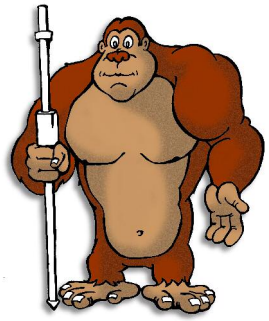
- F-16
- C-17
- C-130
- C-141
- B-52

Pavement must be strong near surface to support high tire pressures (fighters).
Pavement must be strong at depth to support high loads (wide-body).



Impact of Damages/Repairs on Airfield Capability

How do you evaluate this?



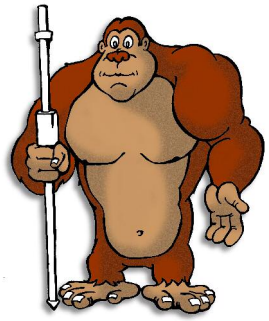
Airfield Pavement Evaluation

- **Many variables in pavement evaluation**

- **Assumptions are made for the unknowns**

- **Many agencies are involved in evaluations**
  - **AFCESA Pavement Evaluation Team**
  - **RED HORSE units**
  - **Air Mobility Operations Groups (AMOGs)**
  - **Tanker Airlift Control Elements (TALCEs)**
  - **Special Tactics Teams (STTs)**
  - **Contingency Response Groups (CRGs)**

- **Must have standards that all involved understand**
- **Operations community deserves consistent answers**

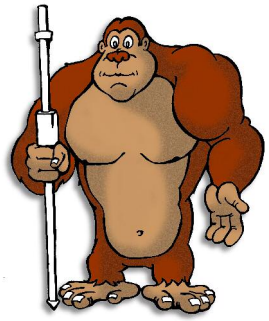


Pavement Evaluation Basic Concepts

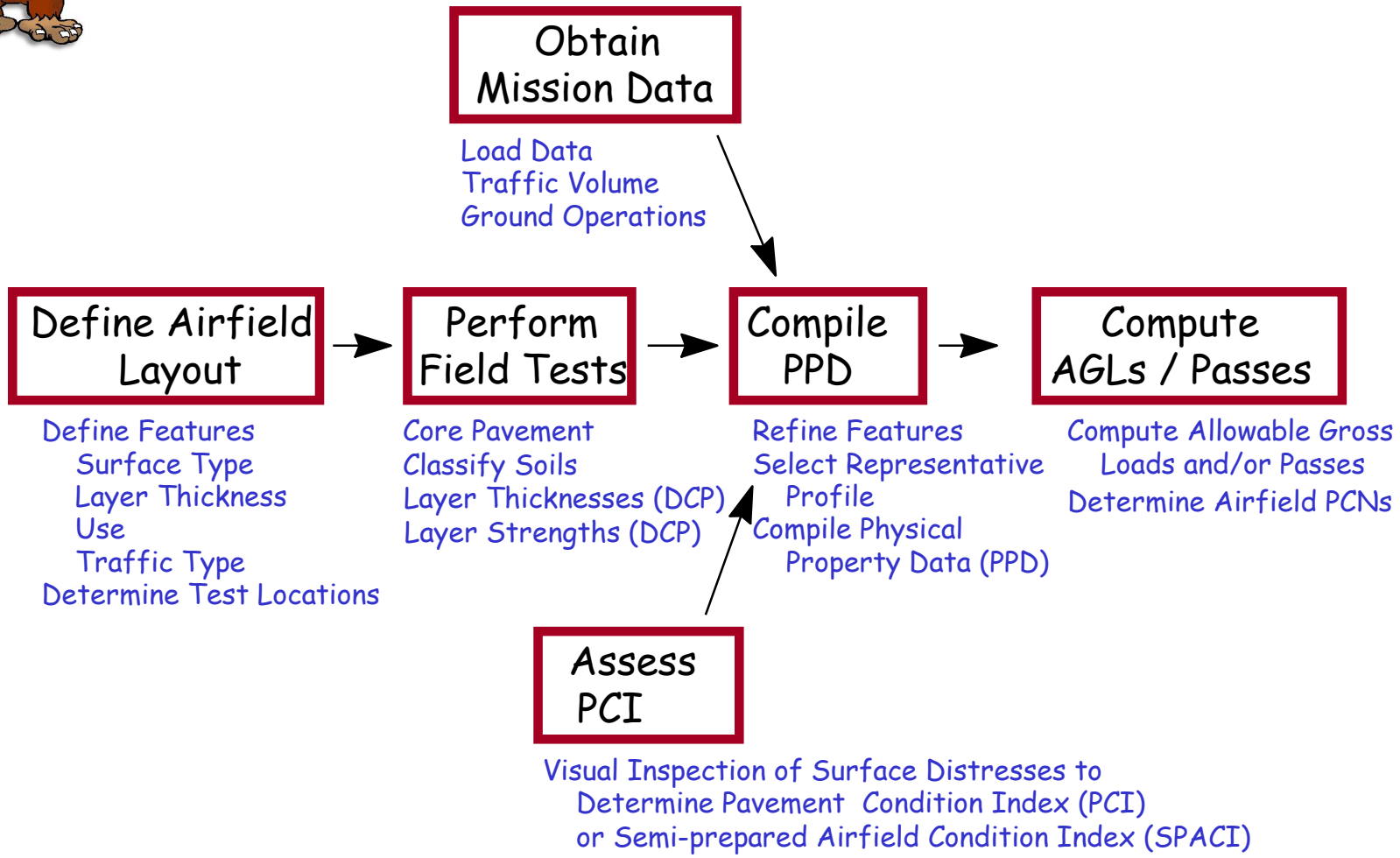
Most concepts developed for design, but they are applicable to evaluation since evaluation is essentially the reverse of design

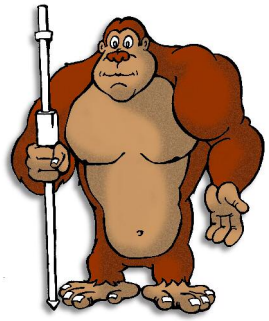
--Design--Know or determine strength, load, and passes; calculate thickness

--Evaluation--Know or determine strength and thickness; calculate load and/or passes

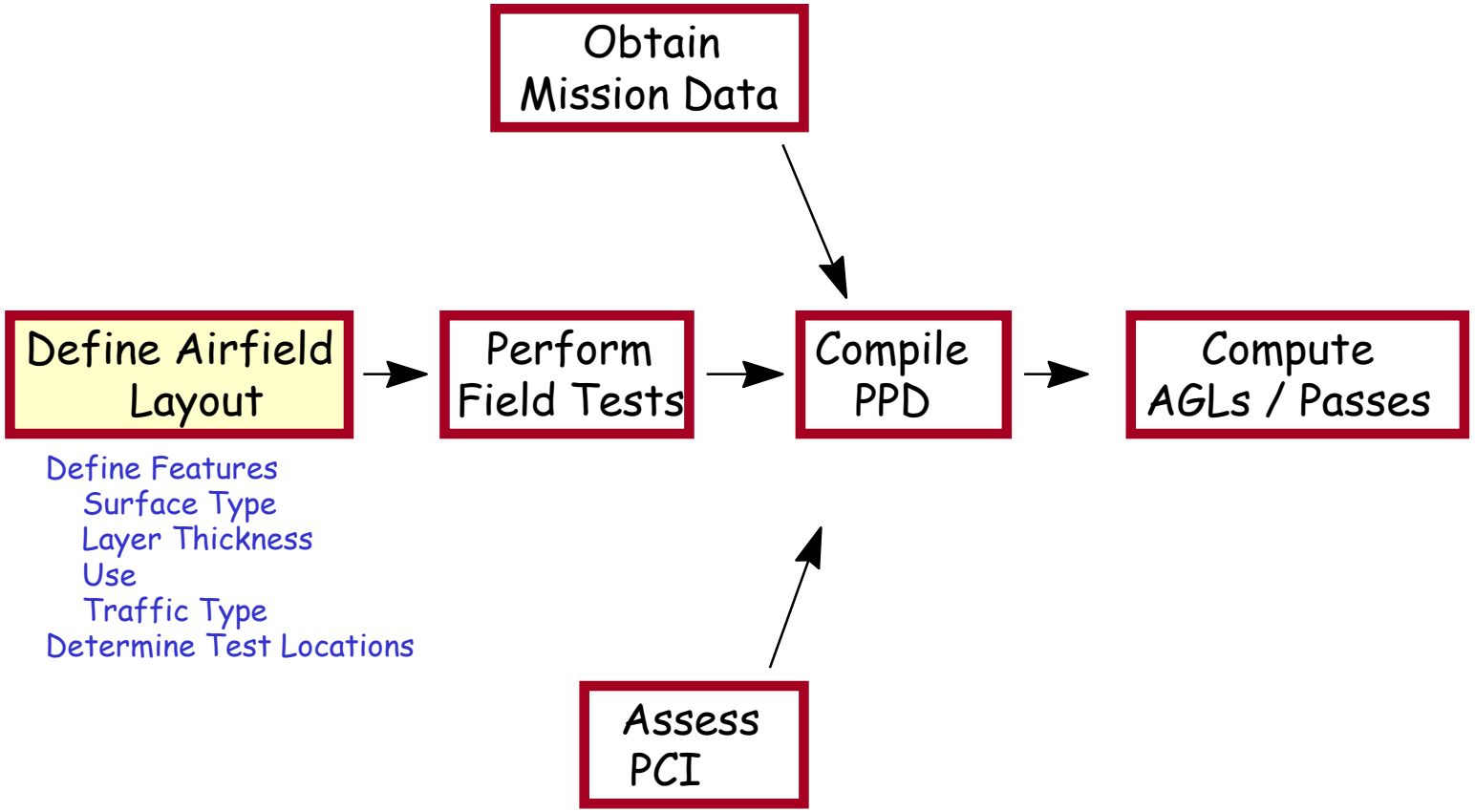


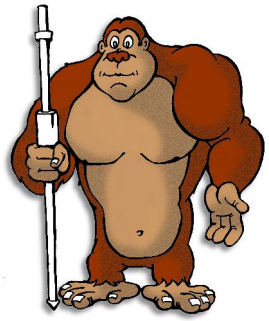
Evaluation Procedures





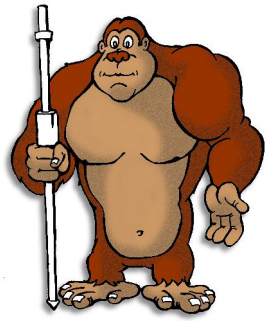
Evaluation Procedures
Define Airfield Layout



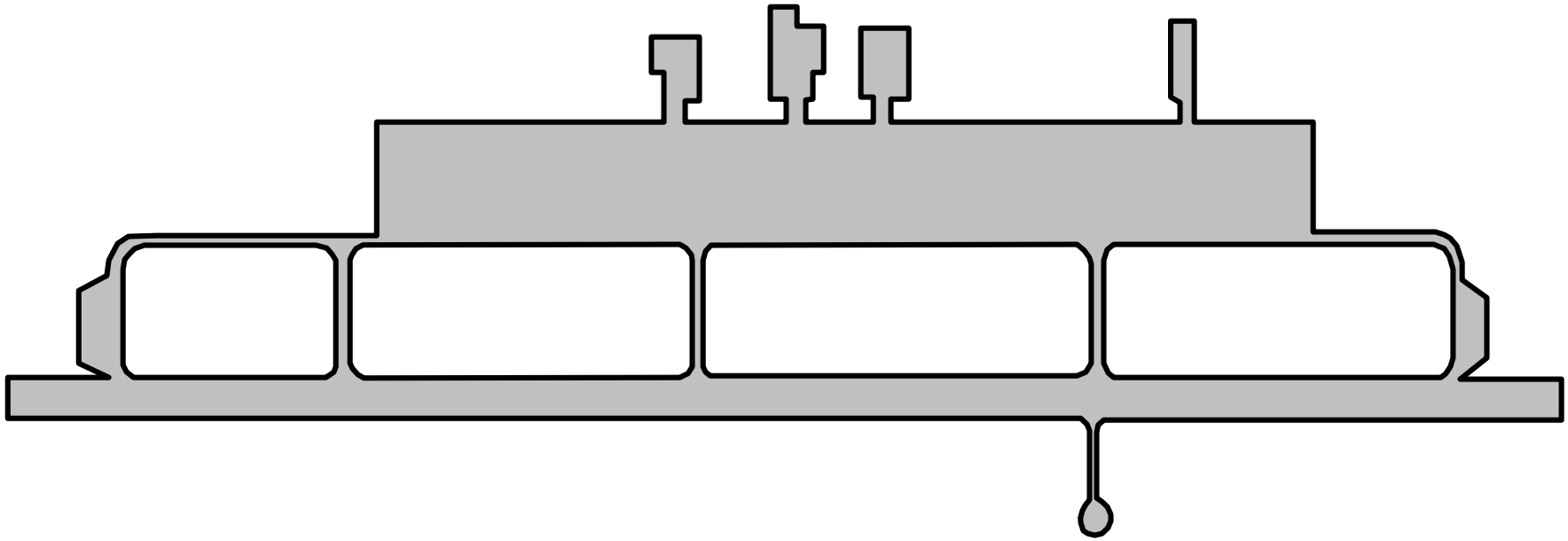


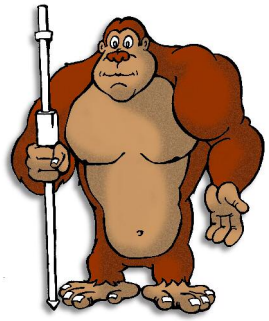
Define Airfield Layout
Initial Look at Airfield

- *Identify operational surfaces and define scope of evaluation*
- *Identify any limiting factors*
  - *Drainage problems*
  - *High severity distresses*
  - *Major repairs*
  - *Unsuitable geometrics*



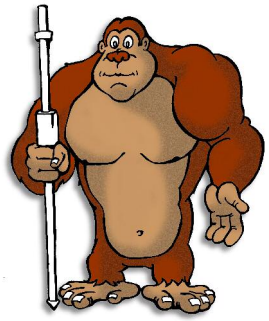
Define Airfield Layout Feature Plan





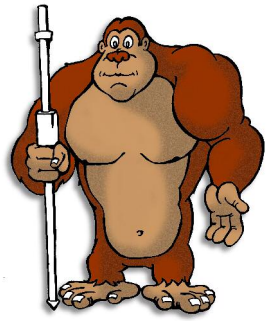
Define Airfield Layout
Define Features

- **Define Features**
  - **Pavement Type, Thickness Condition, and History**
  - **Subsurface Layers**
  - **Pavement Use**
  - **Traffic Type**

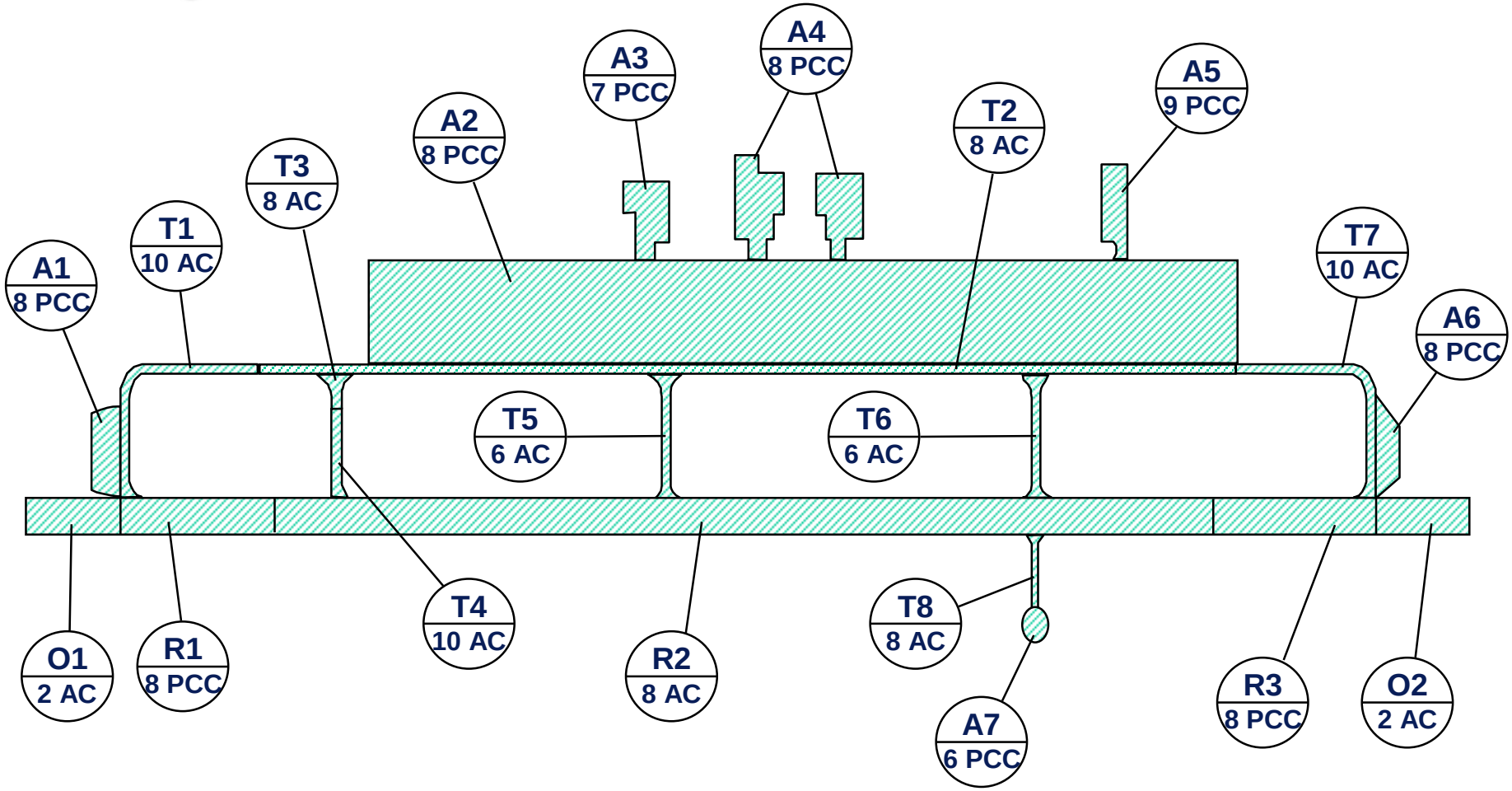


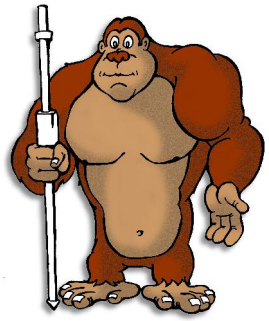
Define Airfield Layout Feature Characteristics

- **Pavement**
  - Type
  - Thickness
  - History
  - Uniform Condition
- **Subsurface Layer**
  - Types
  - Thicknesses
  - Strengths
- **Single Pavement Use**
  - R = Runway
  - O = Overrun
  - T = Taxiway
  - A = Apron
- **Traffic Type**
  - A = Channelized, full weight
  - B = Nonchannel, full weight
  - C = Less than design weight



Define Airfield Layout Feature Plan





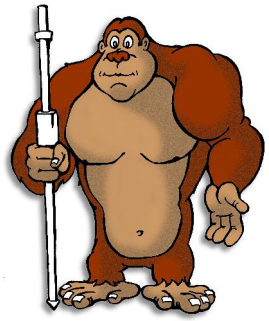
Define Airfield Layout Traffic Types for Evaluation

A = Channelized traffic (70” Wander), Full design weight

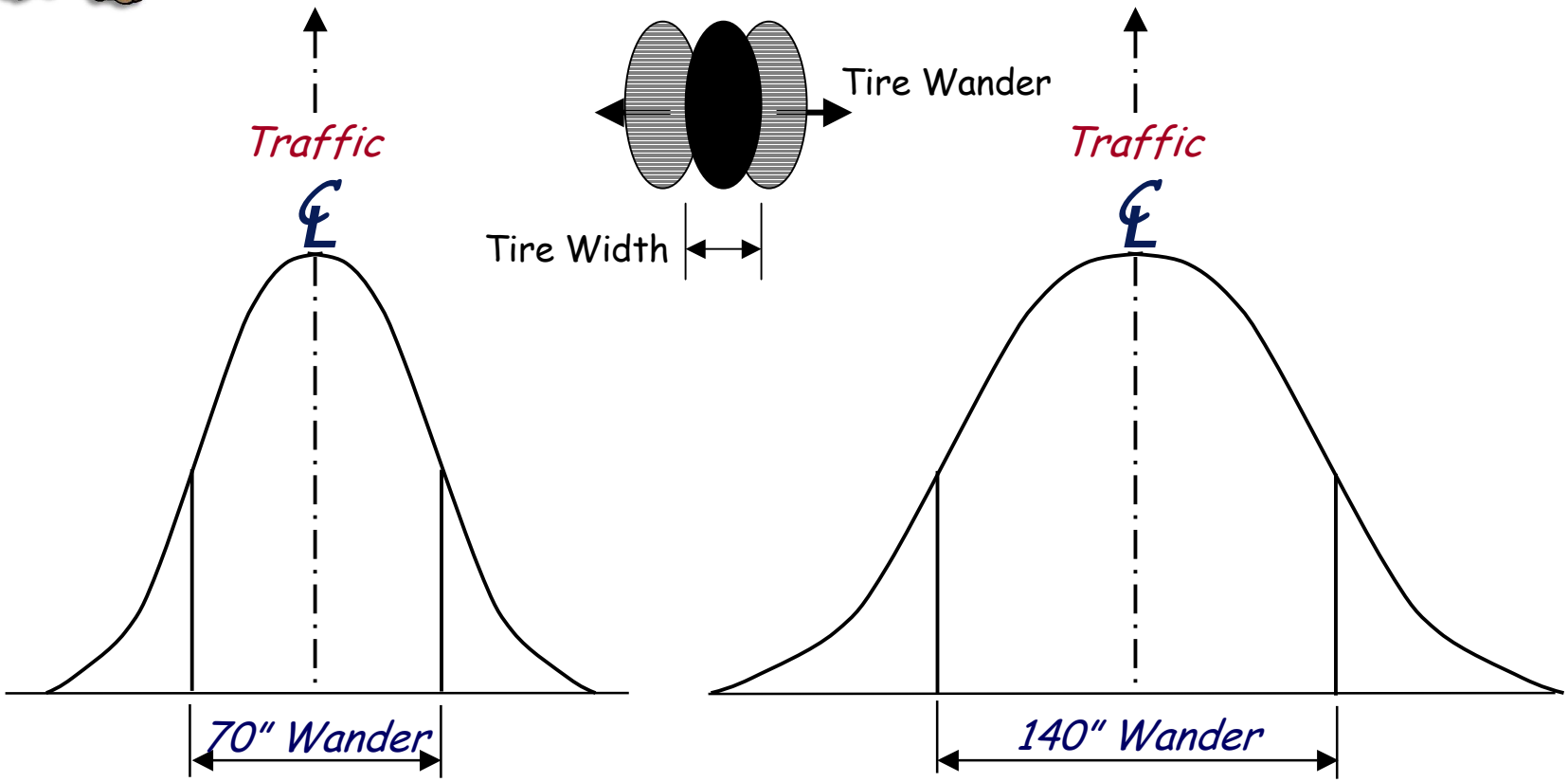
B = Nonchannelized traffic (140” Wander), Full design weight

C = Nonchannelized traffic (140” Wander), Volume of traffic is low or weight is less than design weight (75%)

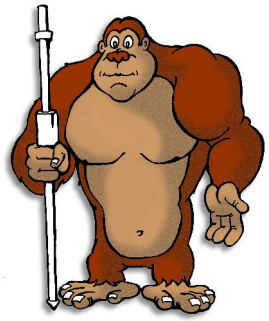
D = Nonchannelized traffic (140” Wander), Weight is less than design weight (75%), Traffic volume is extremely low (1% of A)



Define Airfield Layout
Traffic Types for Evaluation

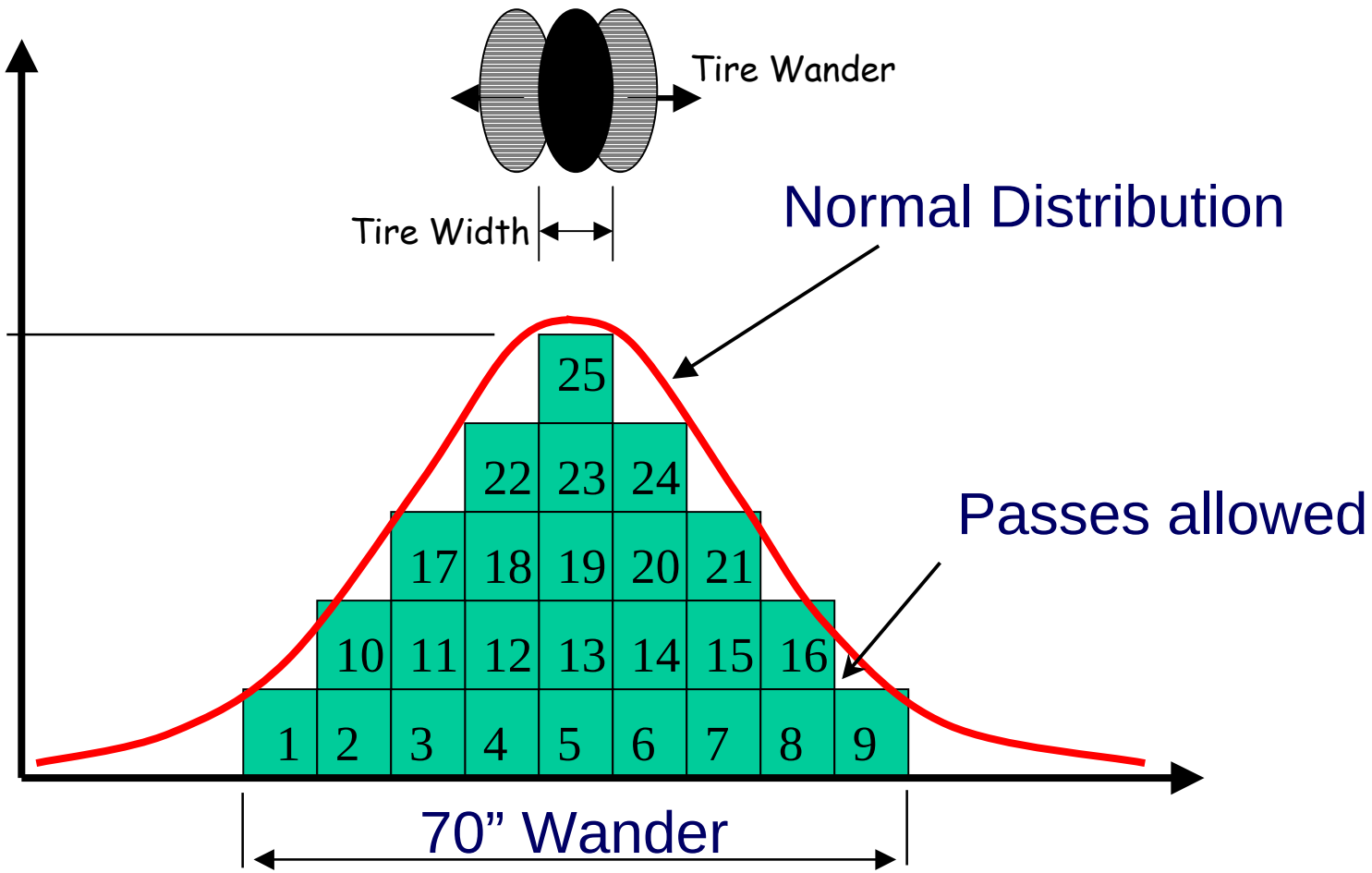


A = Channelized traffic B/C = Nonchannelized traffic

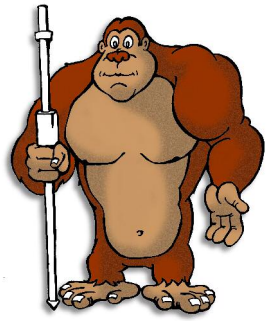


Define Airfield Layout
Traffic Types for Evaluation

Impact on Pavement or Design Stress Level

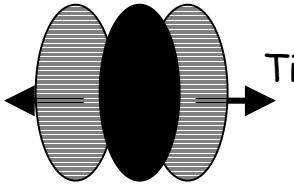


A Traffic Area



Define Airfield Layout
Traffic Types for Evaluation

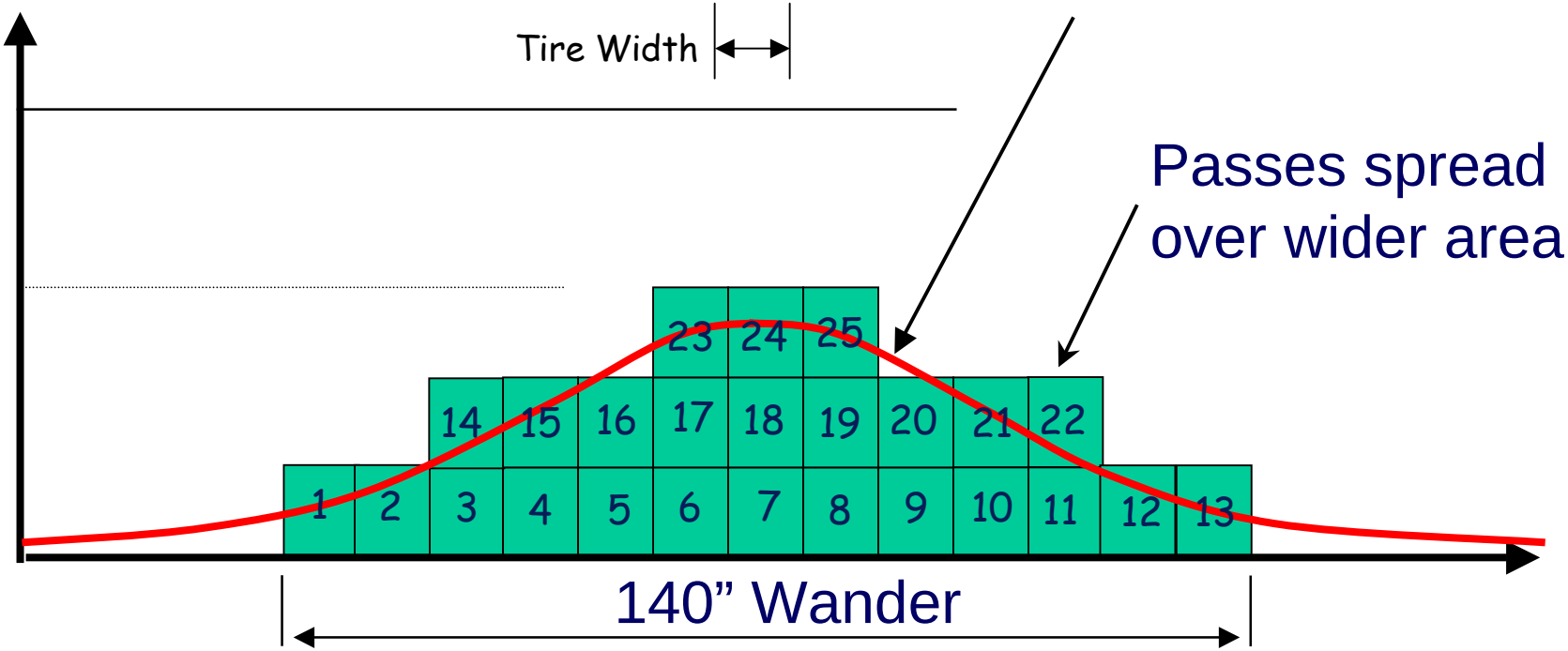
Lower Impact
on Pavement



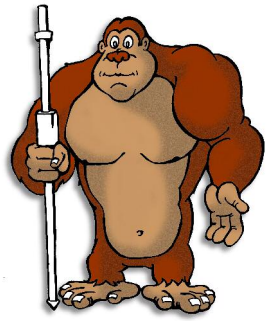
Tire Width

Normal Distribution

Passes spread
over wider area

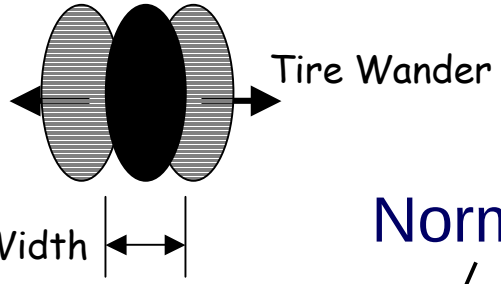


B Traffic Area



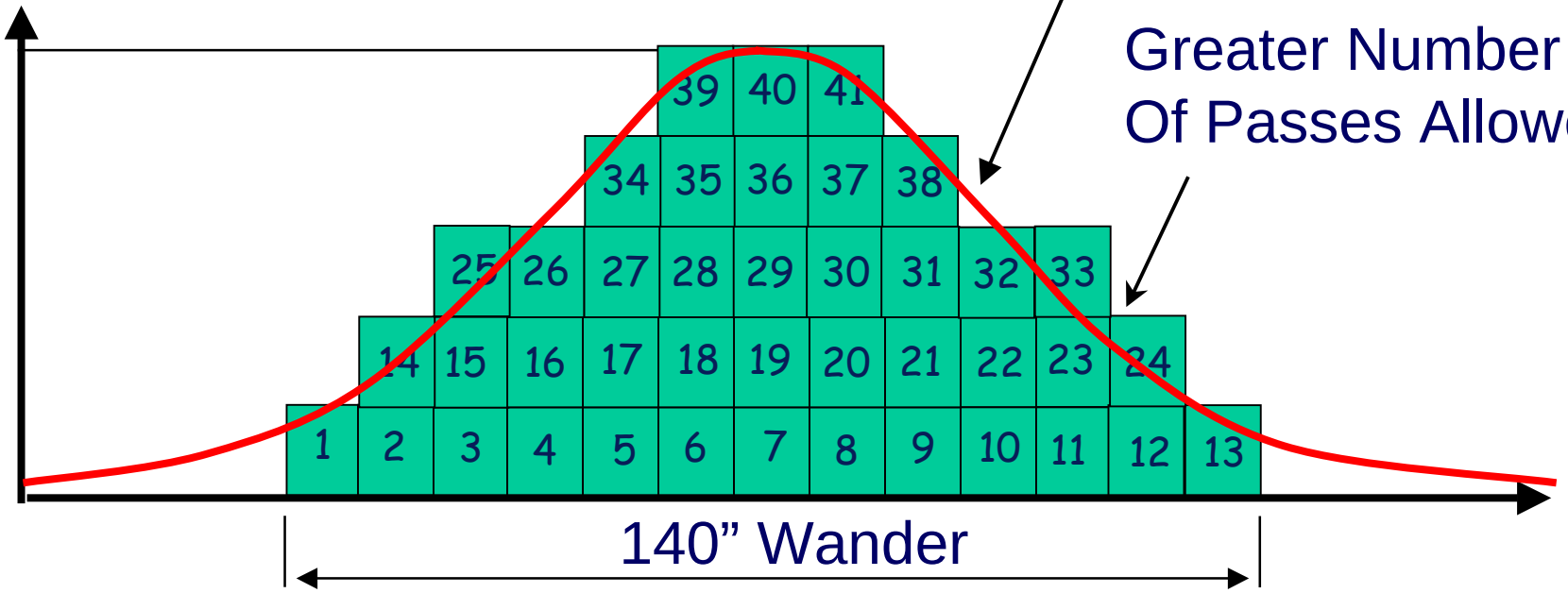
Define Airfield Layout
Traffic Types for Evaluation

Same Impact
as A Traffic

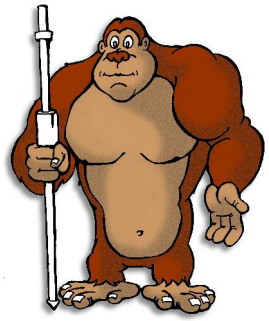


Normal Distribution

Greater Number
Of Passes Allowed

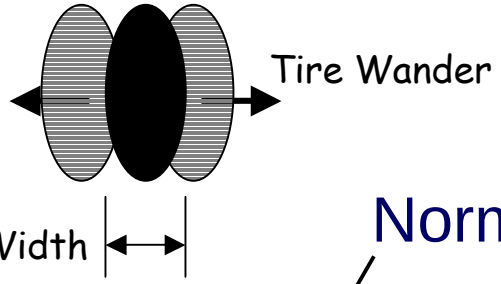


B Traffic Area



Define Airfield Layout
Traffic Types for Evaluation

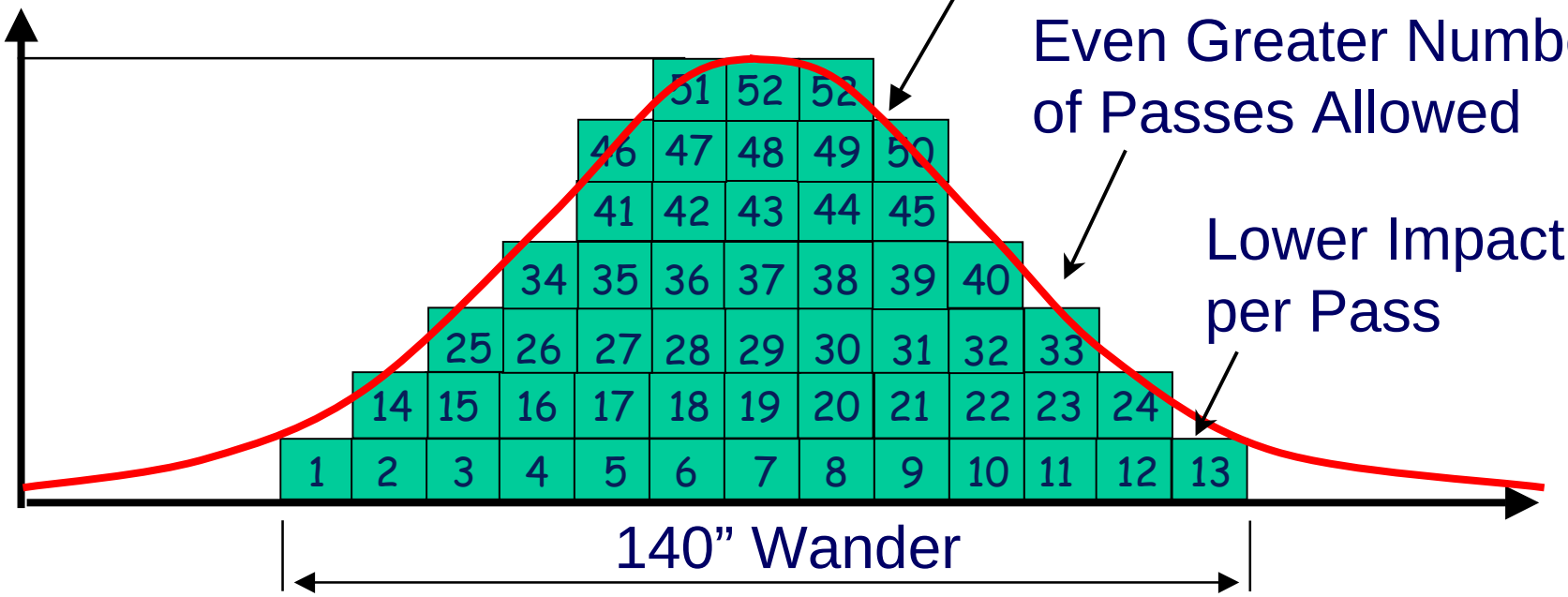
Same Impact
as A Traffic



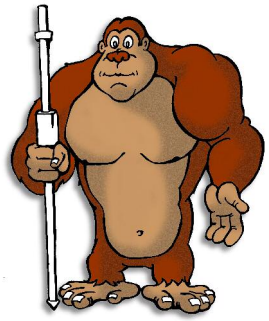
Normal Distribution

Even Greater Number
of Passes Allowed

Lower Impact
per Pass

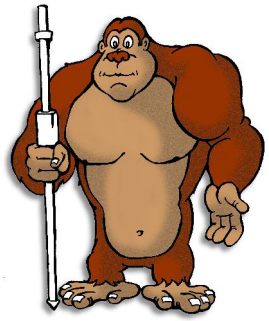


C Traffic Area

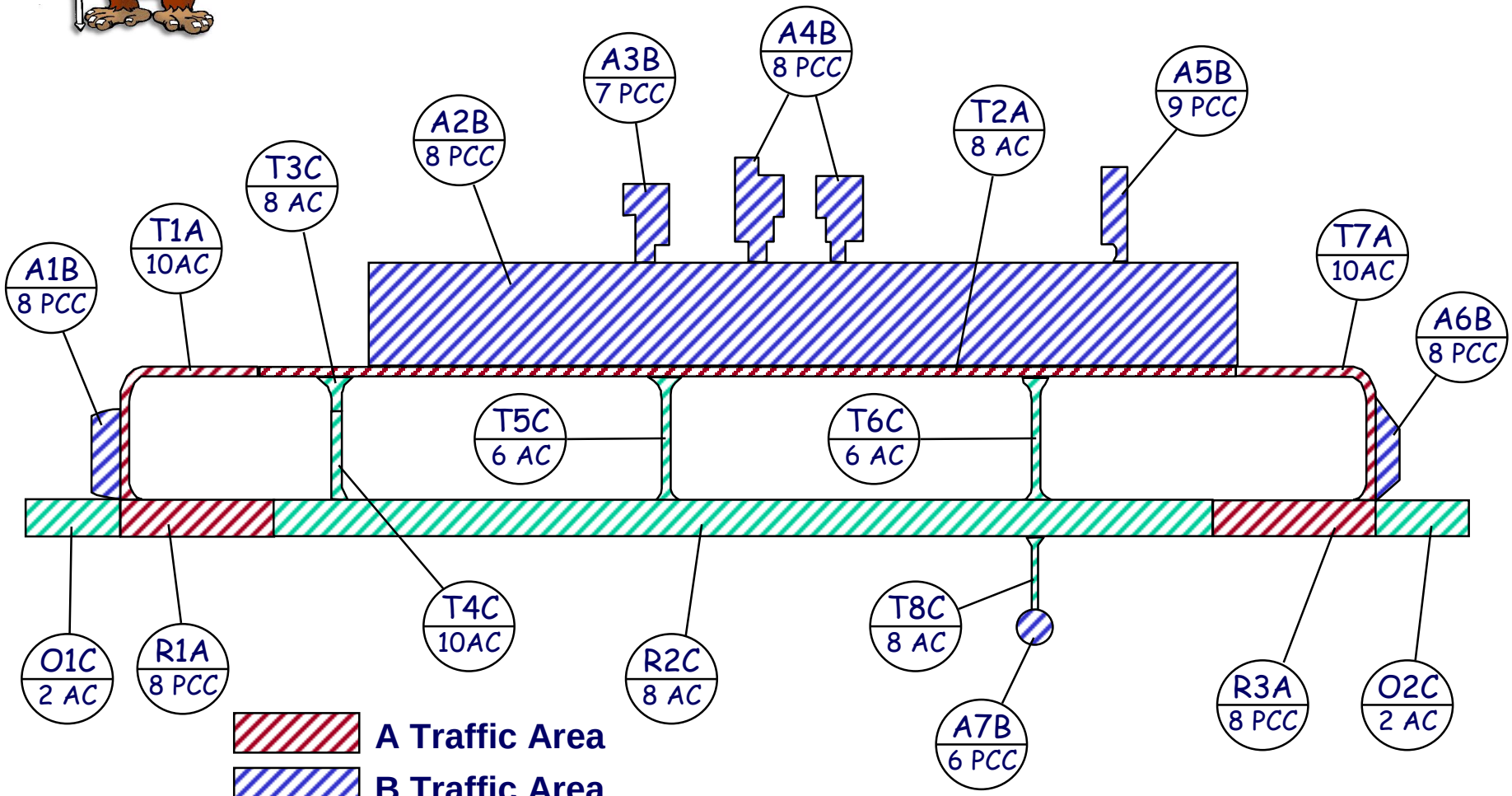


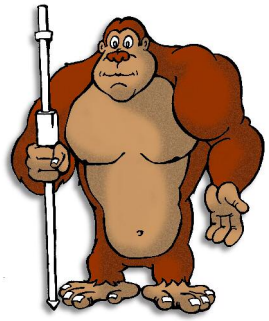
Define Airfield Layout Traffic Types for Evaluation

A Channelized, full weight	- 1000’ Runway ends - Primary Taxiways - Other sections of runway, if required for back-taxi operations - All operational surfaces of semi-prepared or unsurfaced - All operational surfaces for expedient evaluation
B Non-channelized, full weight	- Aprons
C Non-channelized, 75% weight	- Runway interiors (unless used to back-taxi) - Secondary Taxiways - Overruns



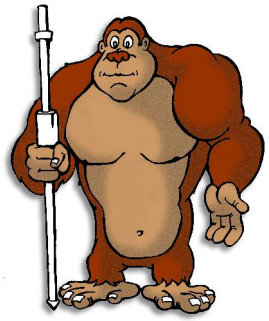
Define Airfield Layout
Traffic Types for Evaluation



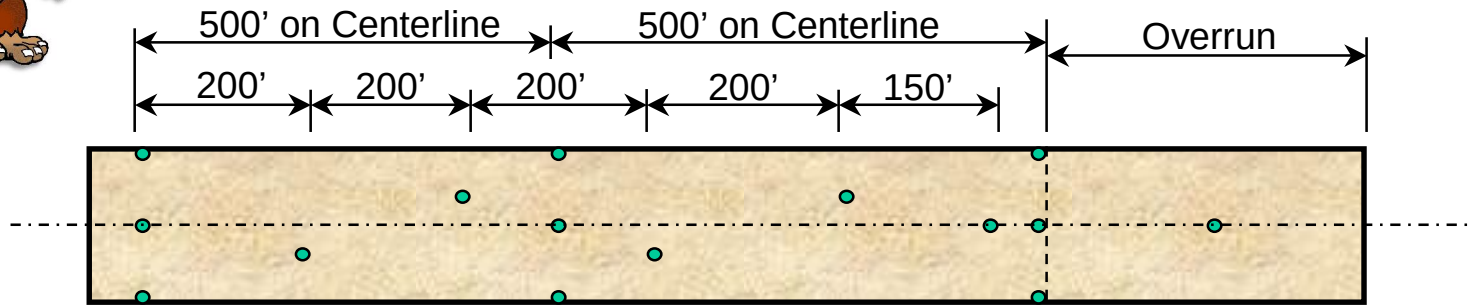


Define Airfield Layout
Determine Test Locations

- **Cover each feature or aspect of the airfield**
- **Test apparent weak areas first, weakest conditions often control the evaluation**
- **Perform as many tests as time permits, prioritize locations**

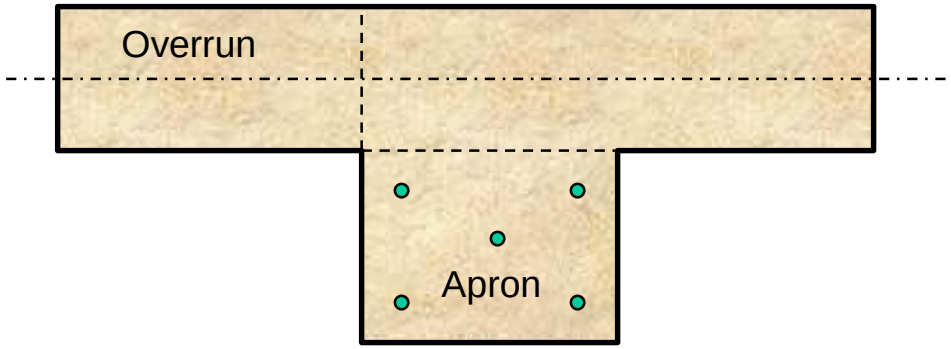


Determine Test Locations Semi-prepared Airfields



Typical Semi-prepared Airfield

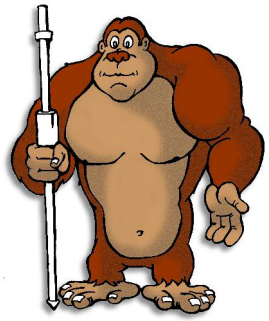
Note: For unimproved airfield, continue this pattern throughout the length. For aggregate surfaced airfields, the pattern may be more widely spaced on the remaining portion of the airfield.



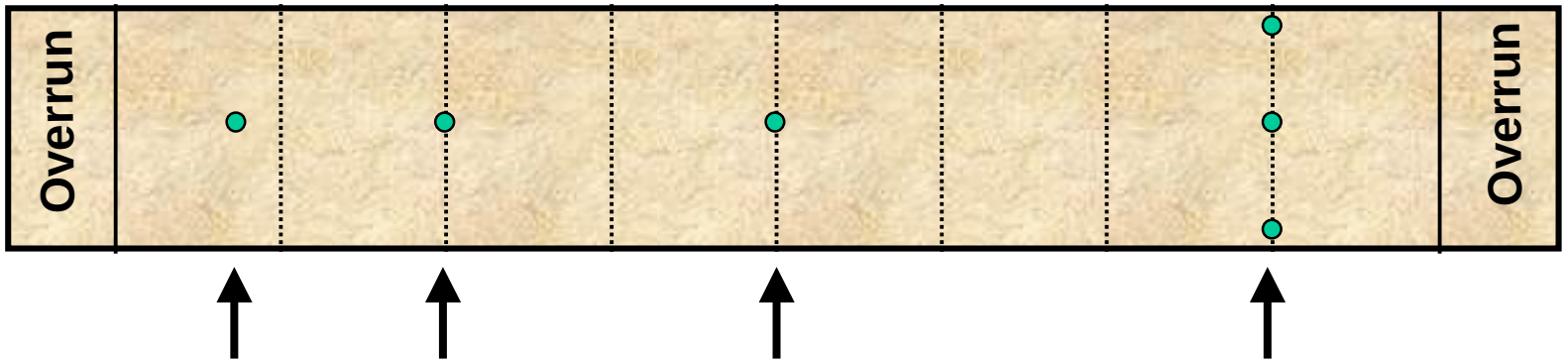
Typical Apron or Turnaround

Priority Testing

1. Soft spots
2. Offsets, should be in wheel paths of main gear
3. Centerline
4. Aircraft turnarounds
5. Any area where the aircraft must stop
6. Overrun,one test in center (if overrun is used as a turnaround or for takeoffs, more tests are required)
7. Along edges, at 500 feet intervals



Determine Test Locations Semi-prepared Airfields

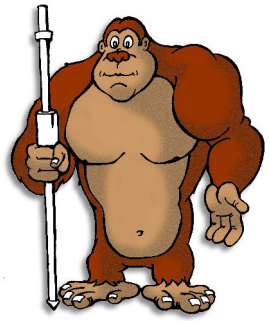


(1) Identified Soft Spots / Wet Areas
(2) Repaired Areas

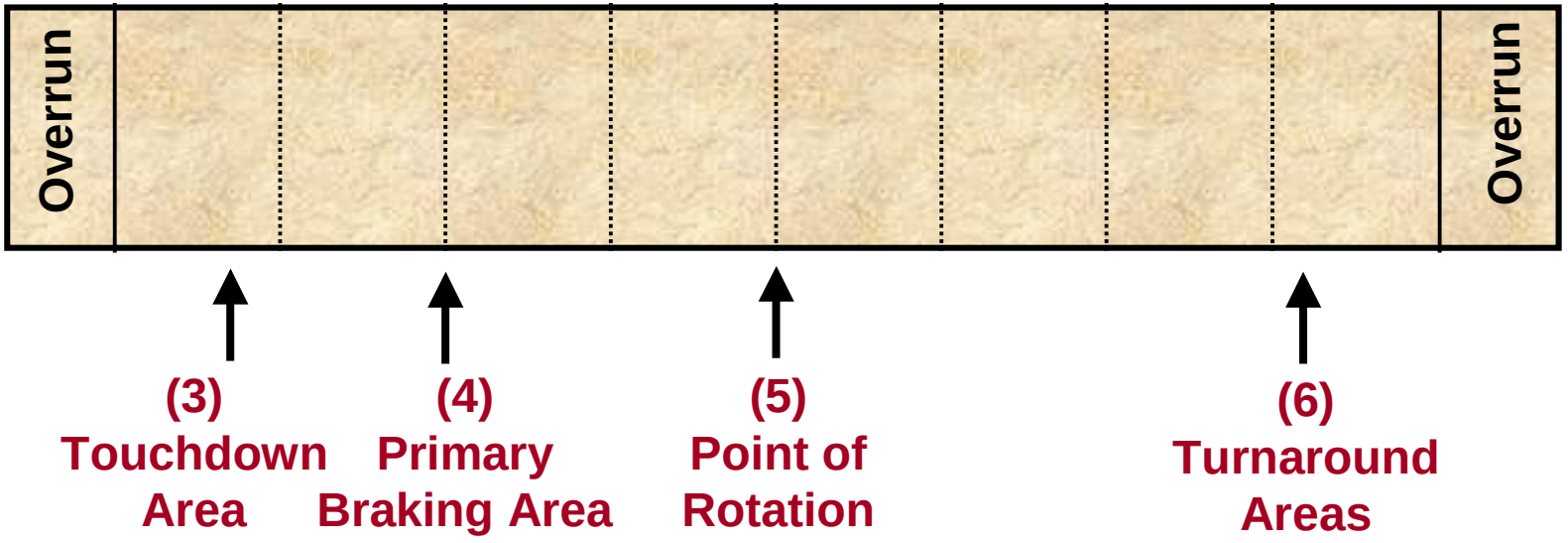
(7) LZ End 50’ from Threshold
(8) Offsets along LZ Centerline

Priority of Test Locations to Validate LZs
When Testing is Limited due to Time Constraints

Perform as many tests as time permits, but prioritize locations

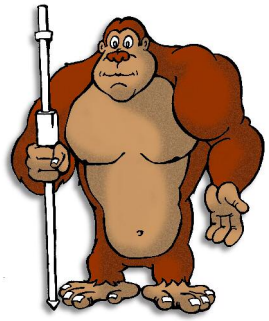


Determine Test Locations Semi-prepared Airfields



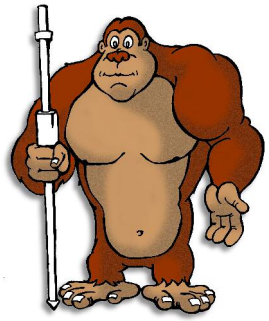
(1) Identified Soft Spots / Wet Areas
(2) Repaired Areas

Minimum Test Locations to Validate Previously Evaluated LZs Prior to Immediate Missions



Determine Test Locations Indicators of Soft Areas

- **Wet areas, look for low areas with potential drainage problems**
- **Areas with discolored soil**
- **Areas with vegetation**
- **Existence of animal burrows (gophers, prairie dogs, snakes) or ant hills**
- **Areas previously forested which may still have excessive subsurface roots and organic materials**
- **Areas with excessive distresses, such as ruts and loose surface material**

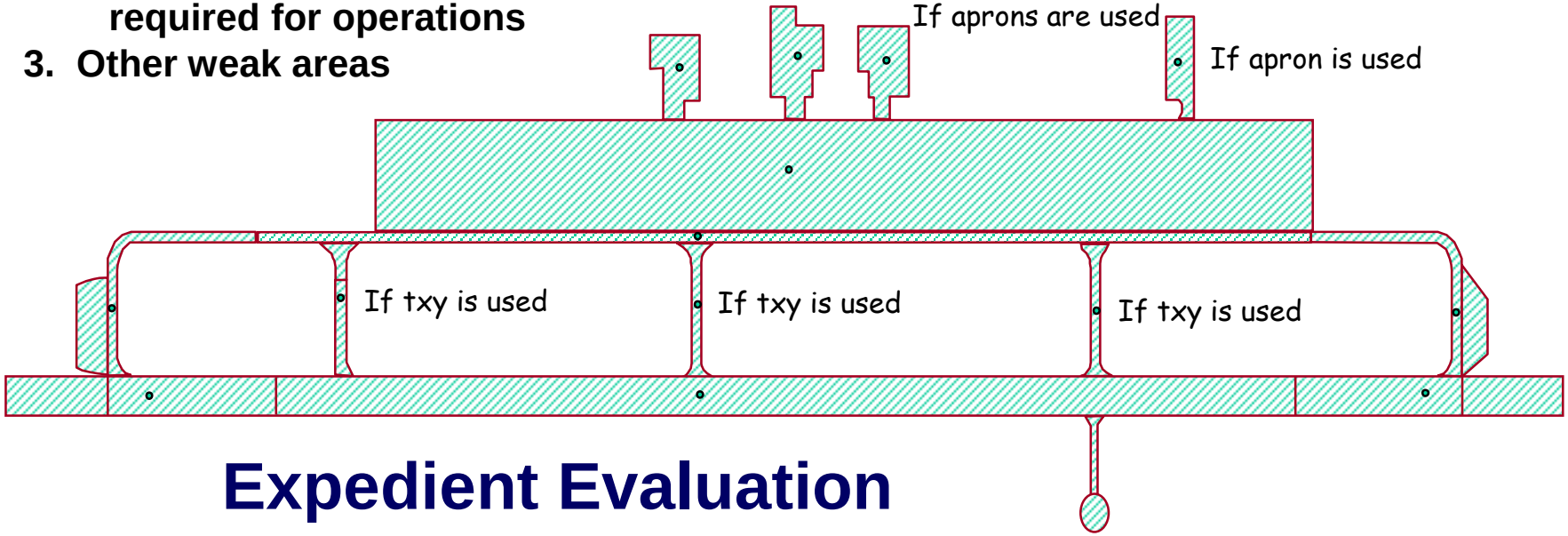


Determine Test Locations Paved Airfields

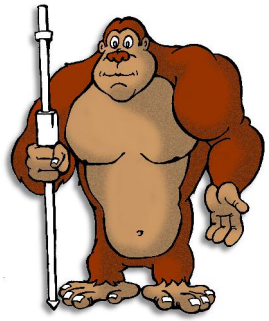
Perform as many DCP tests as time permits, but prioritize test locations to ensure all critical areas are tested.

Priority Testing

1. **Runway**
   a. **Weak areas (drainage problems, high severity level distresses, repaired areas, crater repairs)**
   b. **Threshold/touchdown areas**
   c. **Aircraft turnarounds**
2. **One test for each facility (taxiway or apron) required for operations**
3. **Other weak areas**



Expedient Evaluation

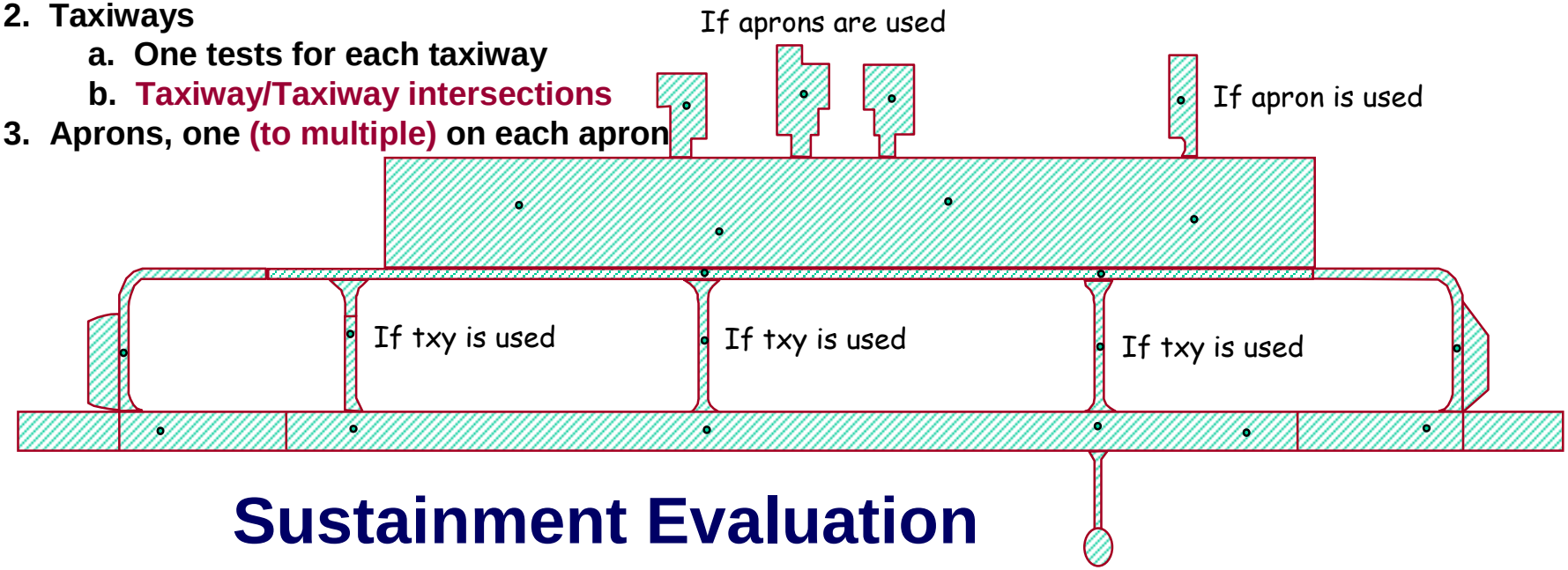


Determine Test Locations Paved Airfields

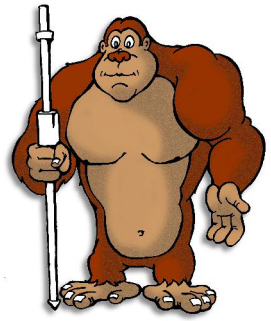
Perform as many DCP tests as time permits, but prioritize test locations to ensure all critical areas are tested. Tests in the touchdown, primary braking,and areas should be performed in the main gear paths. Tests at the Turnaround areas should be conducted near the lateral edges of the pavement as well as along the centerline.

Priority Testing

1. **Runway**
   a. **Soft spots / Weak areas (drainage problems, high severity level distresses, repaired areas, crater repairs)**
   b. **Runway Touchdown Zone , Aircraft turnarounds, Primary braking area, Point of rotation**
   c. **Runway/Taxiway Intersections, Overruns (min 2)**
2. **Taxiways**
   a. **One tests for each taxiway**
   b. **Taxiway/Taxiway intersections**
3. **Aprons, one (to multiple) on each apron**

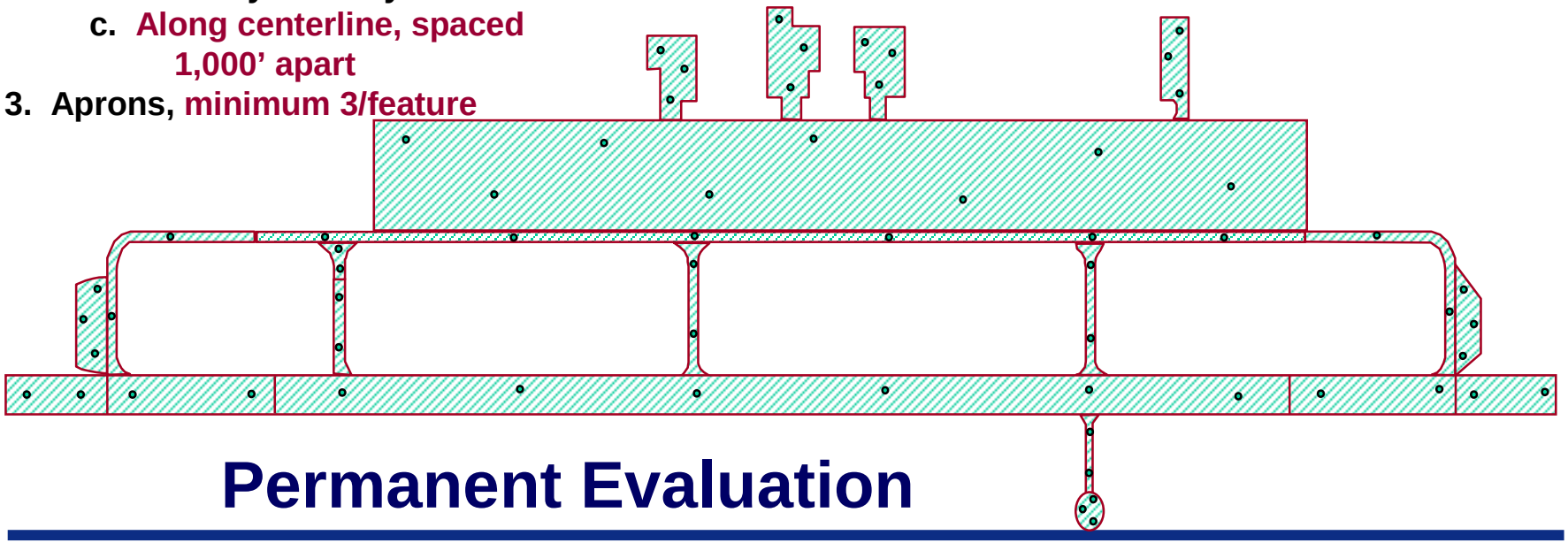


Sustainment Evaluation

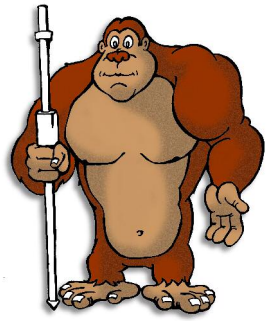


Determine Test Locations
Paved Airfields

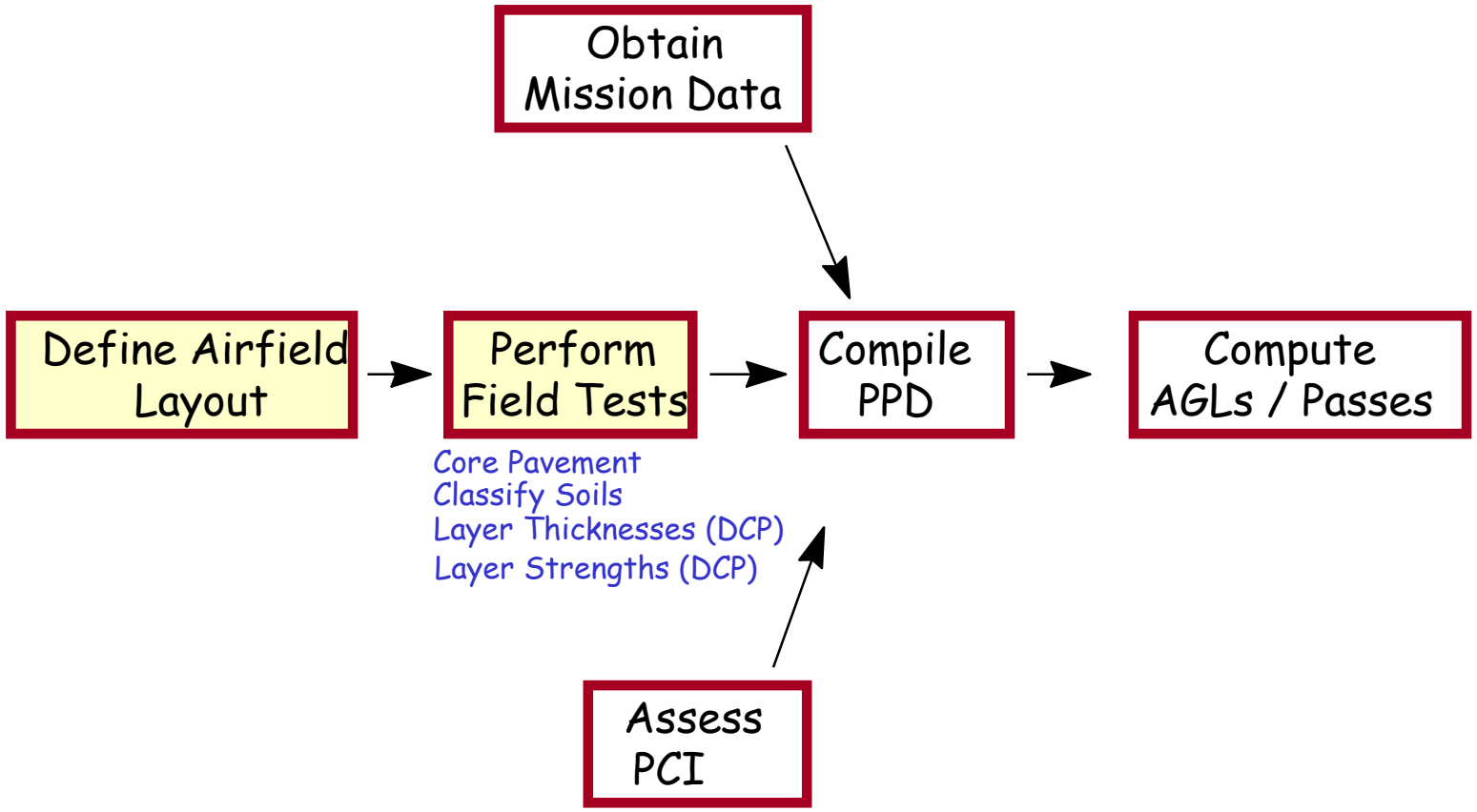
1. Runway
   a. Soft spots / Weak areas (drainage problems, high severity level distresses, repaired areas, crater repairs)
   b. Runway Touchdown Zone (min 2), Aircraft turnarounds, Primary braking area, Point of rotation
   c. Runway/Taxiway Intersections, Overruns (min 2)
   d. In main gear paths spaced 500 to 1000' apart along centerline
2. Taxiways
   a. Min 2 tests for each feature
   b. Taxiway/Taxiway intersections
   c. Along centerline, spaced 1,000' apart
3. Aprons, minimum 3/feature

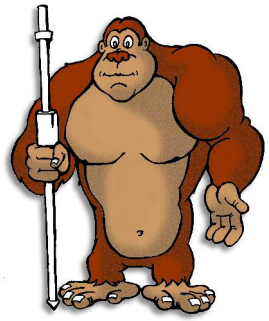


Permanent Evaluation



Evaluation Procedures
Perform Field Tests

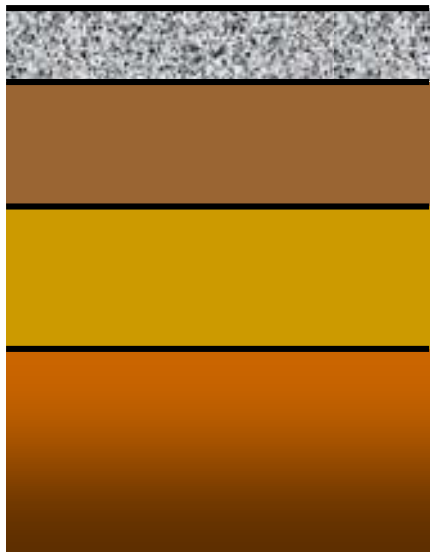




Perform Field Tests
Cross Section for Each Feature

Surface course
- Type
- Thickness
- Condition
- If PCC, need Flex strength

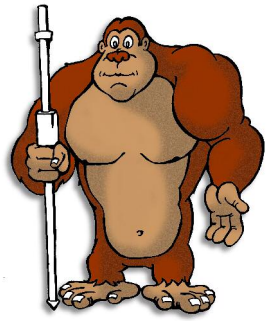
Base Course
- Type
- Thickness
- Strength



Subbase Course(s)
- Type
- Thickness
- Strength

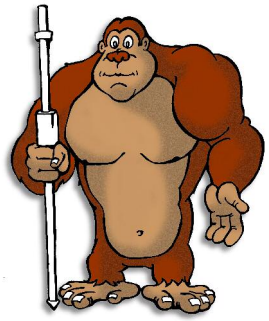
Subgrade
- Type
- Strength

Must establish a typical cross section for each feature to be evaluated



Perform Field Tests

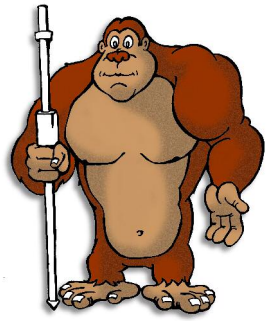
- **Core Pavement**
  - **Identify Pavement Type**
  - **Measure Pavement Thickness**
  - **Access to Subsurface Layers**
- **Evaluate Subsurface Layers**
  - **Identify Soil Type**
  - **Measure Layer Thicknesses**
  - **Determine Layer Strengths using the DCP**



Perform Field Tests Pavement Types

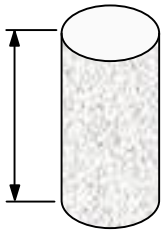
- **Visually Identify Pavement Types**
  - **Flexible (AC)**
  - **Rigid (PCC)**
  - **Composite (PCC over AC over PCC)**
  - **Reinforced Rigid (RPCC)**
  - **AM-2 Mat**
  - **Aggregate / Unsurfaced**
  - **Overlay Combinations**

- **A specific feature contains only one pavement type**

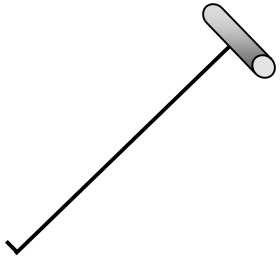


Perform Field Tests
Pavement Thickness

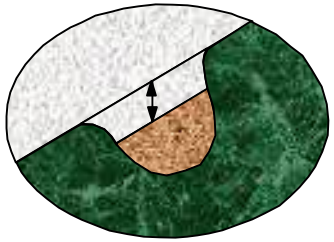
Core to Verify Pavement Thickness



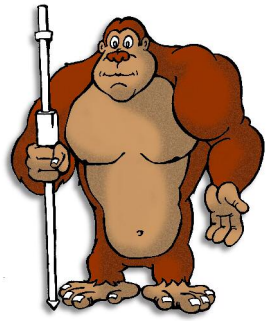
- Take cores in main gear wheel paths
- If PCC, core in center of slab to avoid thickened edges



- If coring is not possible, then drill



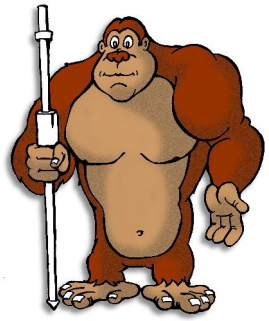
- If can't drill, then assume thickness based upon measurement at pavement edge or construction history data



Perform Field Tests
Pavement Thickness

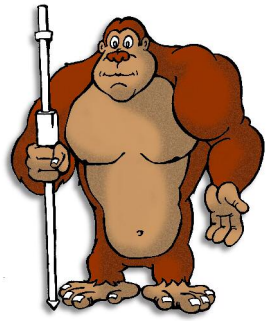
Distance:
Runway Centerline to Main Gear Centerline

4.5’	F-15, F-16, F-111, B-52
7’	C-130, B-1B
9’	F-4, C-141, A-10, 727, 737
11’	KC-135, E-3, 707
12.5’	C-17
18’	C-5, KC-10, 747



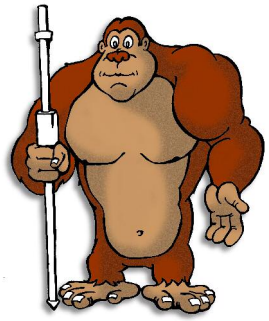
Perform Field Tests Pavement Strength

- **Flexible Pavement**
  - **Judge quality based upon its ability to withstand traffic loads, fuel spillage, and jet blast damage**
- **Rigid Pavement**
  - **Must have flexural strength to evaluate**
  - **If not available, assign based on:**
    - **Type of aggregate and bonding**
    - **Severity of structural distresses**
    - **Stateside, Good QC: 700 PSI**
    - **Uncertain QC: 600 PSI**
- **For expedient evaluations, do not assume existence of reinforcing if you do not see it**



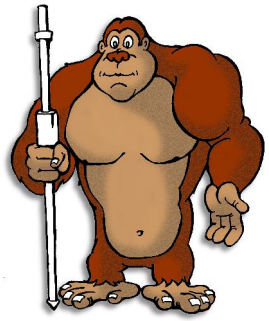
Perform Field Tests Soil Layer Type

- Field identify base, subbase, and subgrade materials using Unified Soil Classification System (USCS)
  - For DCP CBR Correlations, need to identify CL or CH material
  - For frost susceptible regions, must know soil types
  - To determine stabilization methods / amounts
- If results are not clear, obtain samples for laboratory testing
- Identify altered materials such as:
  - Crushed rock
  - Stabilized layers



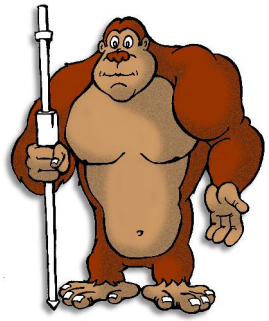
Perform Field Tests
Soil Layer Thickness

- **Measure actual thickness through core holes or excavate at pavement edge**
- **Use Dynamic Cone Penetrometer (DCP) to determine**
- **Other sources of strata information**
  - **Ditches**
  - **Excavations**
  - **Soil Boring data**



Perform Field Tests
Soil Layer Strength, CBR

- California Bearing Ratio (CBR) is used as an empirical measure of soil strength or its resistance to shearing under load
- To determine the CBR, a dynamic load is applied to a 3in^2 end area piston, forcing it to penetrate the soil at a given rate. The load required in PSI to force penetration gives the modulus of shear which is converted to a CBR value using established load factors
- CBR value is expressed as a ratio in percent from 0 to 100 with crushed, well-graded limestone serving as the benchmark material with a CBR of 100.
- CBRs in excess of 100 will not be used.



Perform Field Tests Soil Layer Strength

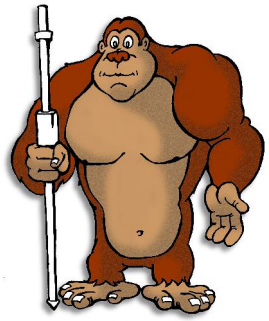
For contingency evaluations, field tests are performed to determine CBR strength values of supporting soil layers

- **The measured CBR values are used to evaluate flexible pavements and semi-prepared surfaces**
- **The CBRs are converted to K-Values (Modulus of Soil Reaction) to evaluate rigid pavements**
- **Field Methods to Determine CBR**
  - **Airfield Cone Penetrometer (ACP)**
  - **Dynamic Cone Penetrometer (DCP)**
  - **Automated Dynamic Cone Penetrometer (ADCP)**
  - **Electronic Cone Penetrometer (ECP)**
  - **Small Aperture CBR Test**
  - **Unified Soil Classification System (USCS)**

Perform Field Tests
Airfield Cone Penetrometer

Perform Field Tests
Dynamic Cone Penetrometer

Integrity - Service - Excellence

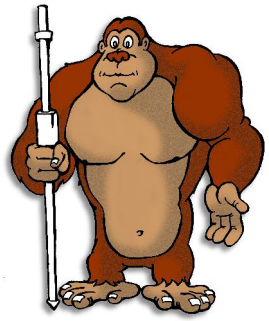


Perform Field Tests Automated DCP

Latest version of DCP, developed to facilitate evaluation of semi-prepared airfields for C-17 operations, reduces manpower required to perform to one person.

Manual operation

Automated data collection

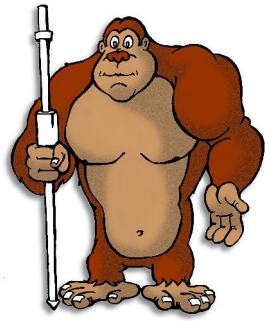


Perform Field Tests
Automated DCP

Depth of penetration determined by digital tape measure

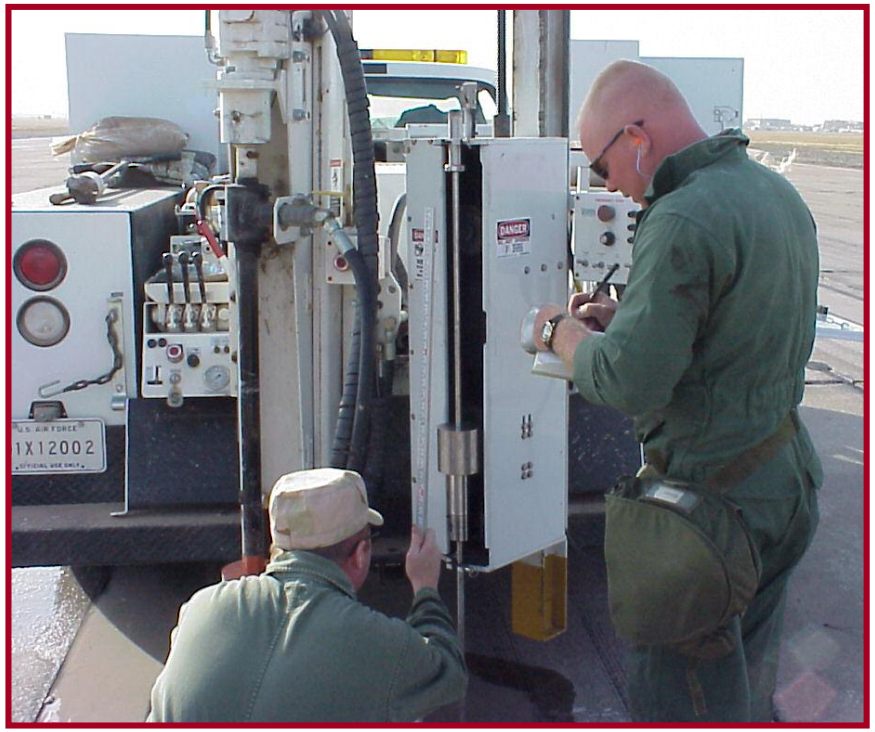
Number of drops determined by microphone

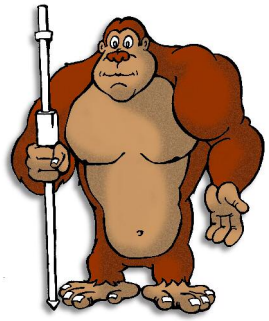
Data recorded on palm size computer or laptop



Perform Field Tests Automated DCP Truck

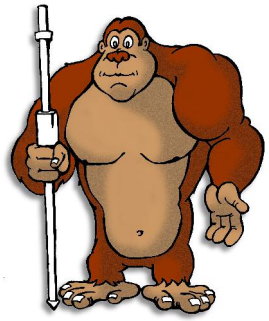
- Automatically operated hammer drives tip into soil
- Correlates to CBR



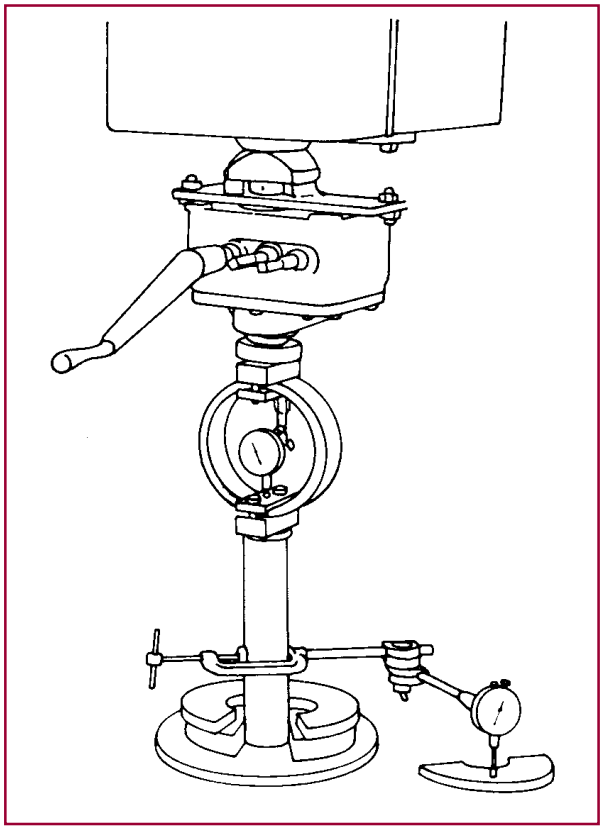


Perform Field Tests
Electronic Cone Penetrometer

- ECP correlation classifies soil type and layer thickness & strength
- Typically penetrate 5 – 10 feet



Perform Field Tests Small Aperture CBR



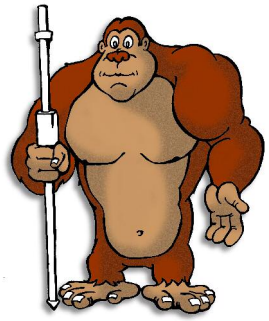
CBR Apparatus

For each test location:

- Drill three holes, minimum
- Setup and run CBR test at multiple depths in all holes, usually every six inches or change in layer type

Time consuming:

- Can take several hours to run tests at a given location



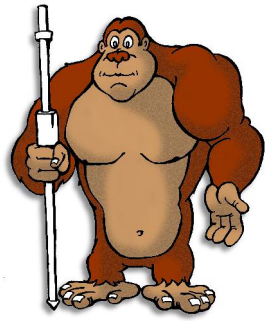
Perform Field Tests
USCS

Soil Characteristics Pertinent to Roads and Airfields

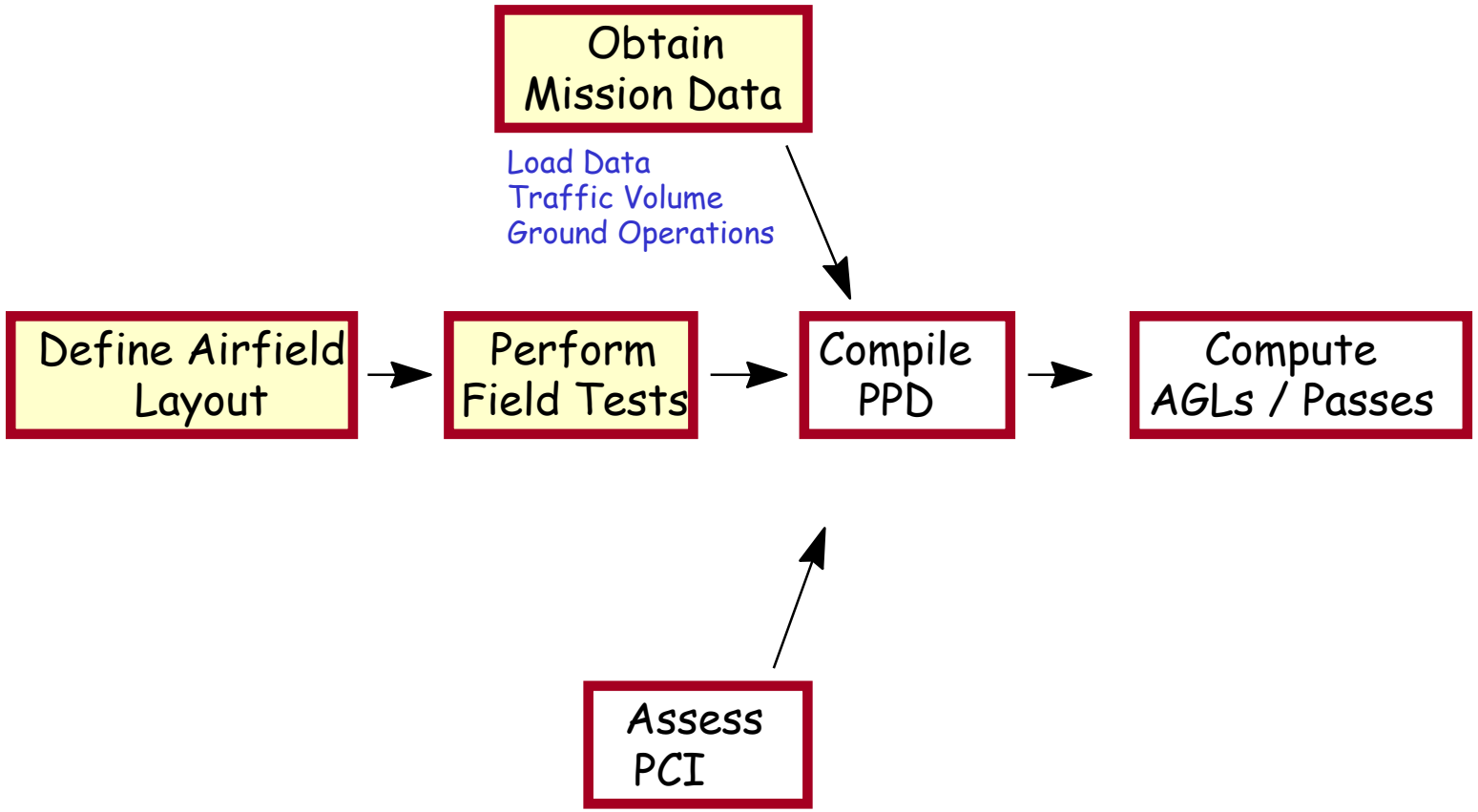
Soil Types		Symbol	Drainage Characteristics	Unit Dry Weight Lb per Cu Ft	Field CBR	Subgrade Modulus K Lb per Cu In
Coarse-grained Soils	Gravels and Gravelly Sands	GW	Excellent	125 - 140	60 - 80	300 or more
		GP	Excellent	110 - 130	25 - 60	300 or more
		GM d	Fair to poor	130 - 145	40 - 80	300 or more
		GM u	Poor to impervious	120 - 140	20 - 40	200 to 300
		GC	Poor to impervious	120 - 140	20 - 40	200 to 300
	Sands and Sandy Gravels	SW	Excellent	110 - 130	20 - 40	200 to 300
		SP	Excellent	100 - 120	10 - 25	200 to 300
		SM d	Fair to poor	120 - 135	20 - 40	200 to 300
		SM u	Poor to impervious	105 - 130	10 - 20	200 to 300
		SC	Poor to impervious	105 - 130	10 - 20	200 to 300
Fine-grained Soils	Silts and Clays LL <50	ML	Fair to poor	100 - 125	5 - 15	100 to 200
		CL	Impervious	100 - 125	5 - 15	100 to 200
		OL	Poor	90 - 105	4 - 8	100 to 200
	Silts and Clays LL >50	MH	Fair to poor	80 - 100	4 - 8	100 to 200
		CH	Impervious	90 - 110	3 - 5	50 to 100
		OH	Impervious	80 - 105	3 - 5	50 to 100
Highly Organic Soils		Pt	Fair to poor	-----	-----	-----

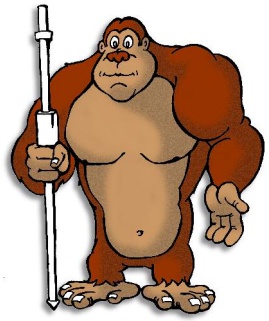
GM and SM groups are divided into subdivisions d and u for roads and airfields
Suffix d is used when LL ≤ 28 and PI ≤ 6 Suffix u is used when LL > 28

Least Accurate Method



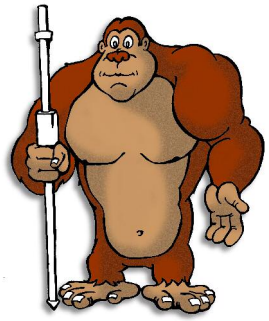
Evaluation Procedures
Obtain Mission Data





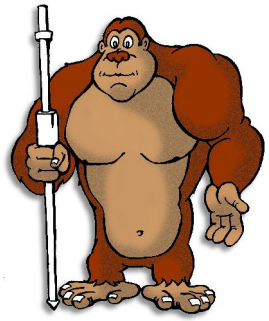
Obtain Mission Data

- **Aircraft Types**
  - **Gear configuration**
- **Loads**
  - **Gross Weight including Fuel and Cargo**
- **Traffic Volume**
  - **Missions and Layout determines Passes**
- **Ground Operations**
  - **Turn-arounds**
  - **Back-taxiing**
  - **Apron / Taxiway Usage**



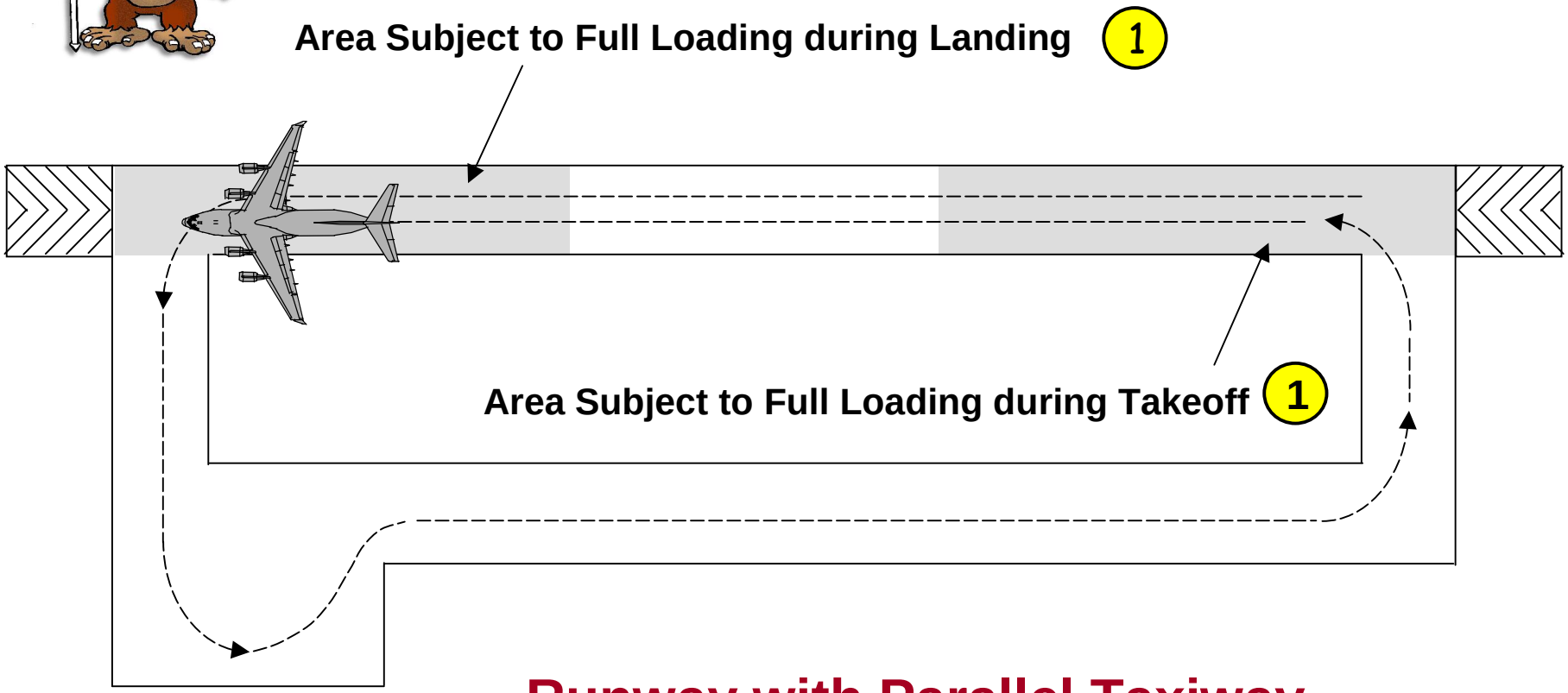
Obtain Mission Data
Aircraft Characteristics

Aircraft	Minimum Weight	Maximum Weight	Length	Wingspan	Runway Length	Runway Width	Taxiway Width
F-15C	28.7k	68k	63.8	42.8	10,000	150	75
F-15E	31.7k	81k	63.8	42.8	10,000	150	75
F-16C/D	16.9k	37.5k	49.5	32.7	10,000	150	75
F-117A	33.8k	49k	65.9	43.3	10,000	150	75
A-10	28k	51k	53.3	57.5	10,000	150	75
B-1B	189k	477k	146.0	137.0	10,000	150	75
B-2A	110k	336.5k	69.0	172.0	10,000	150	75
B-52H	230k	488k	160.4	185.0	10,000	300	75
C-5	375k	837k	247.1	222.9	6,000	148	75
C-17	279k	585k	174.0	169.8	3,500	90	60
C-130	69k	175k	97.8	132.6	3,000	60	30
C-141	144.5k	345k	168.3	160.0	6,000	98	50
KC-10A	270.8k	590k	181.6	165.3	7,000	148	75
KC-135R	104.3k	302k	136.2	130.9	7,000	148	75



Obtain Mission Data

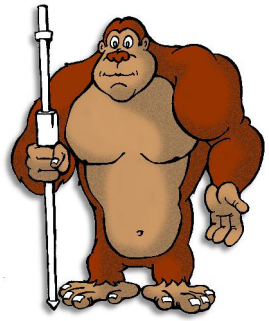
Mission and Layout Determine Passes



Runway with Parallel Taxiway

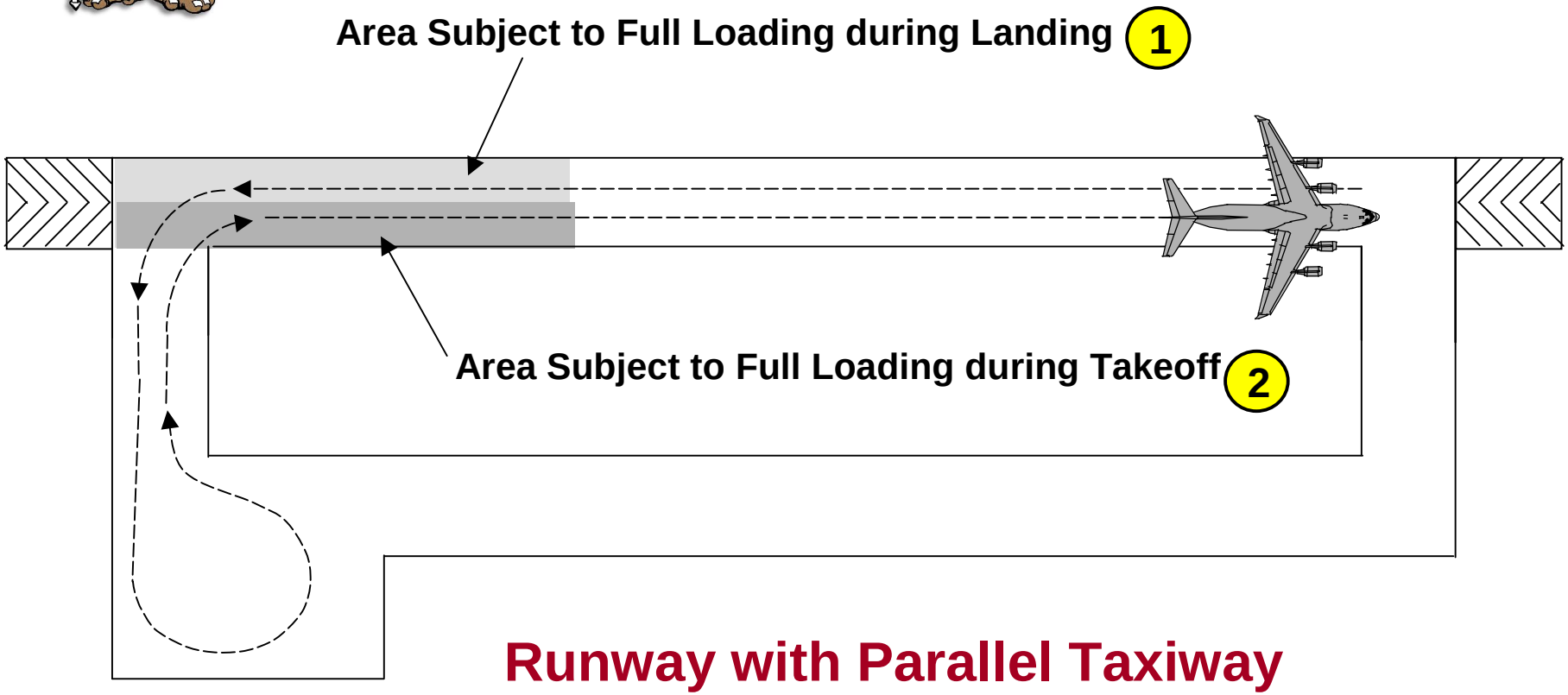
(with no change in wind direction)

One mission or traffic cycle = 1 pass



Obtain Mission Data

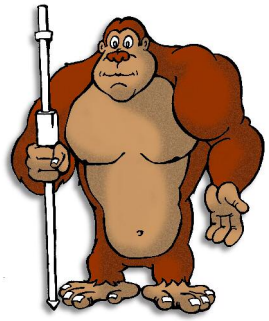
Mission and Layout Determine Passes



Runway with Parallel Taxiway

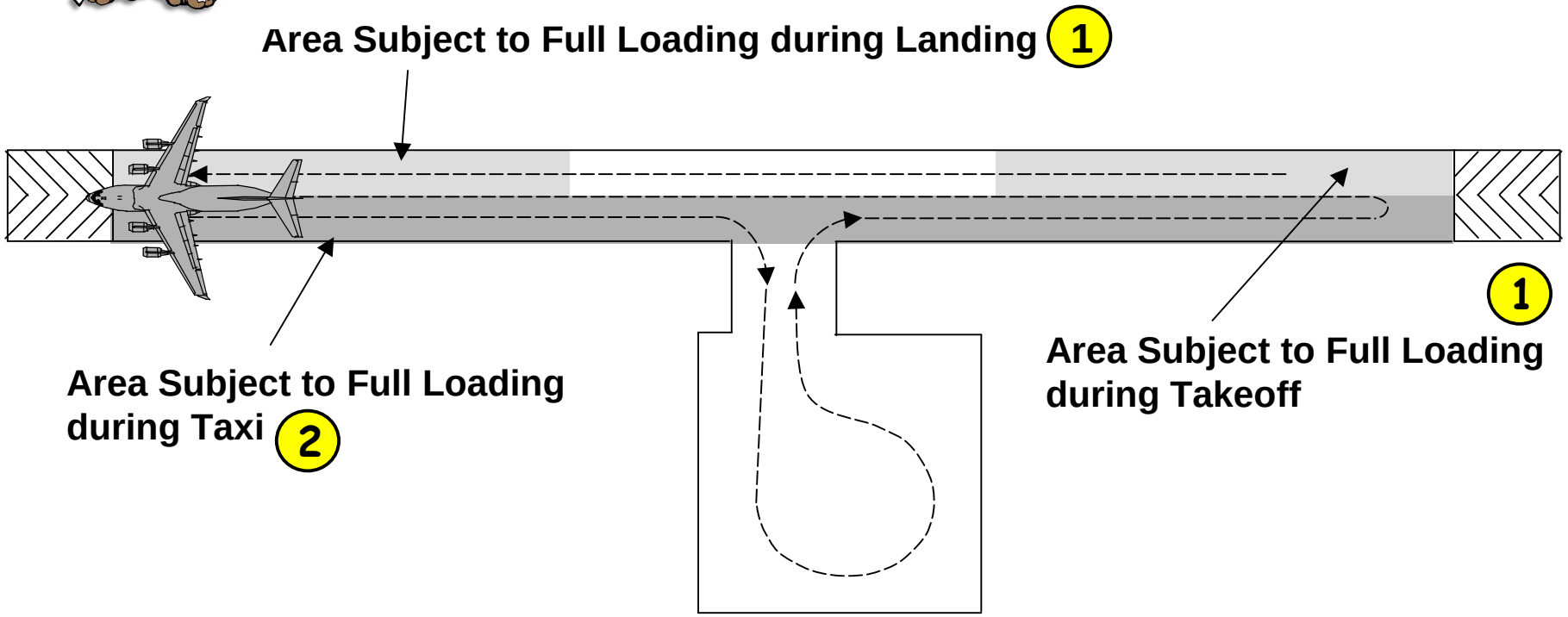
(with change in wind direction)

One mission or traffic cycle = 2 passes



Obtain Mission Data

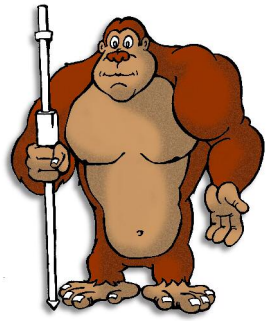
Mission and Layout Determine Passes



Runway with Central Taxiway

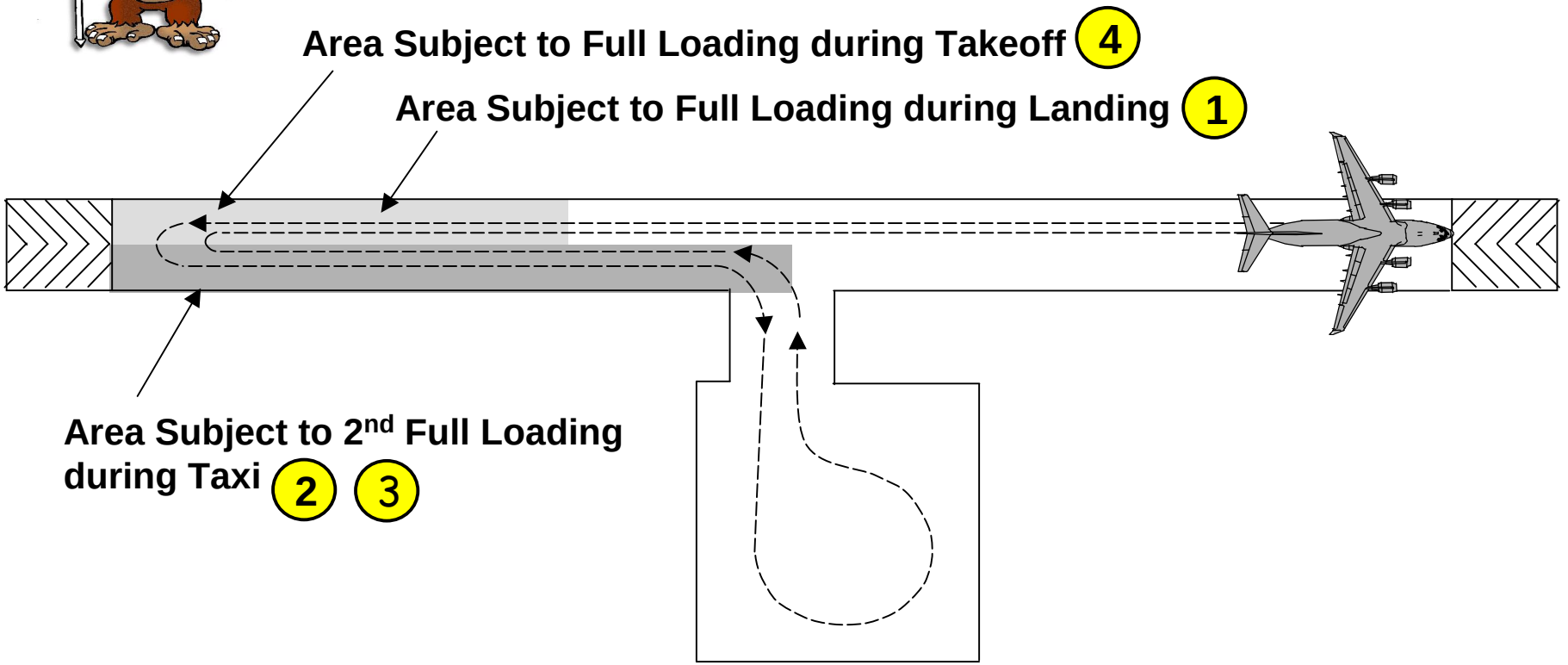
(with no change in wind direction)

One mission or traffic cycle = 2 passes



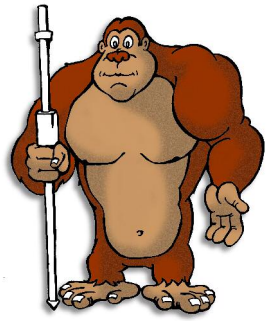
Obtain Mission Data

Mission and Layout Determine Passes



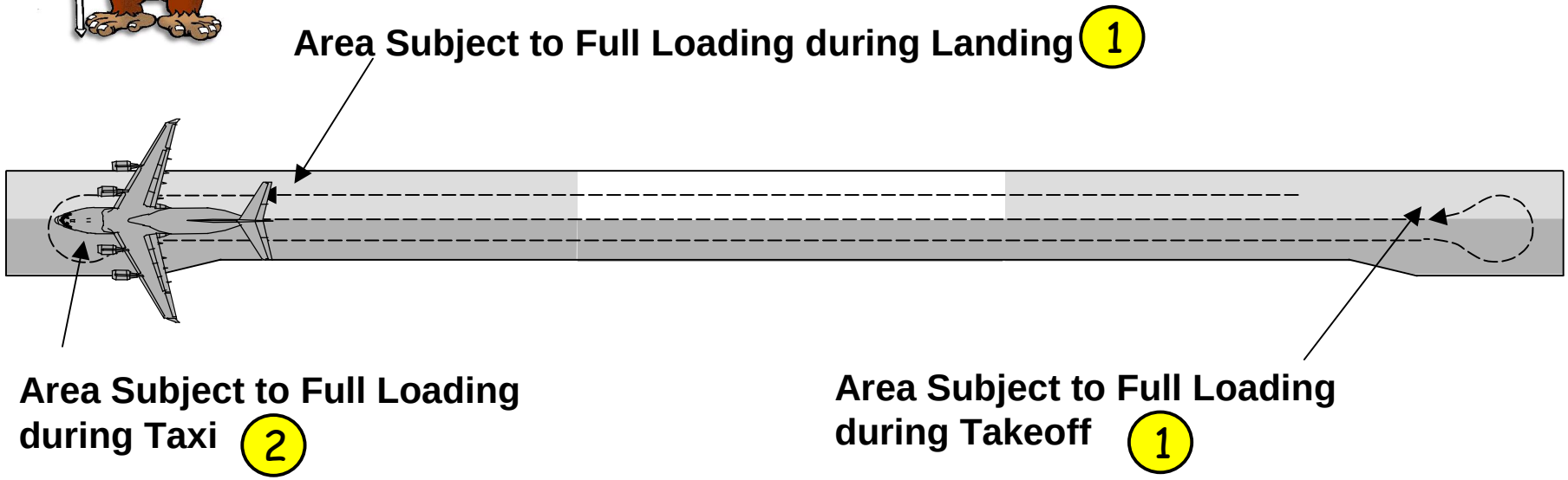
Runway with Central Taxiway
(with change in wind direction)

One mission or traffic cycle = 4 passes



Obtain Mission Data

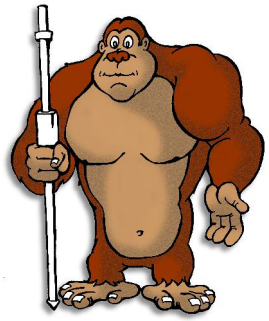
Mission and Layout Determine Passes



Runway with Hammerheads

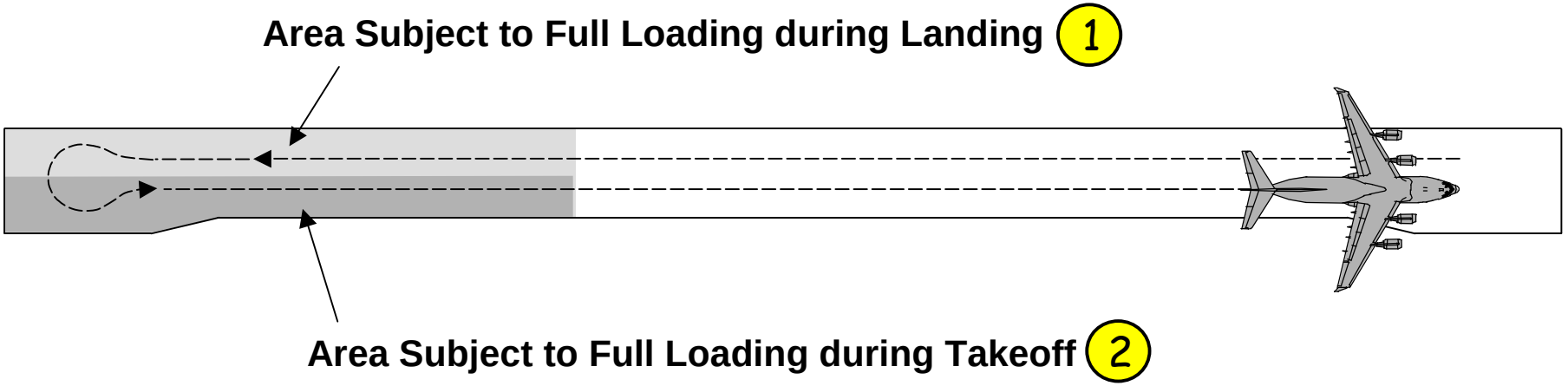
(with no change in wind direction)

One mission or traffic cycle = 2 passes



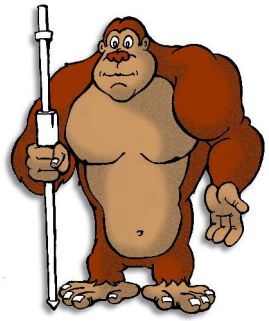
Obtain Mission Data

Mission and Layout Determine Passes

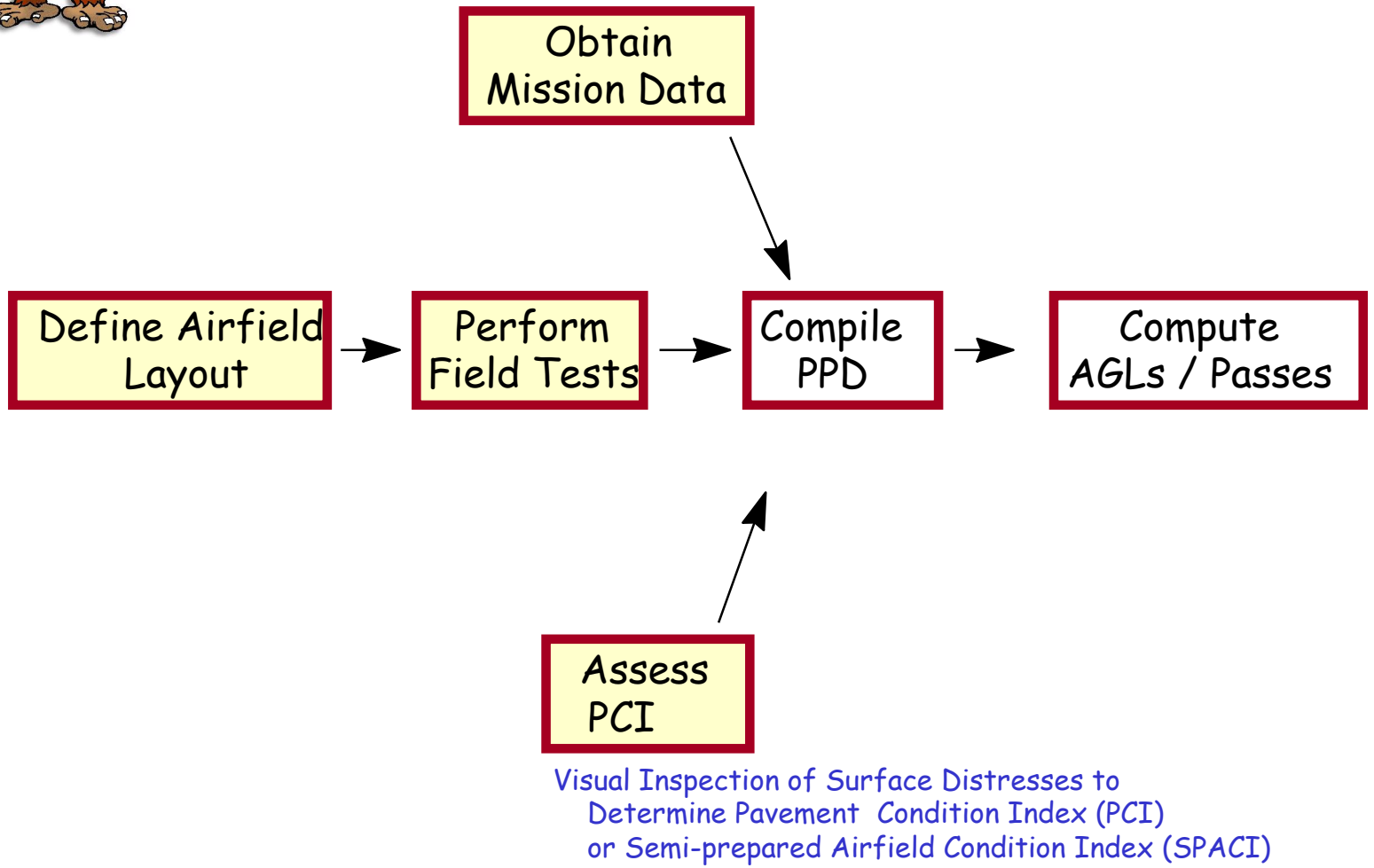


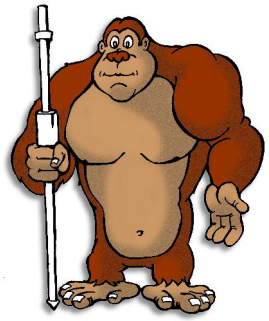
Runway with Hammerheads
(with change in wind direction)

One mission or traffic cycle = 2 passes



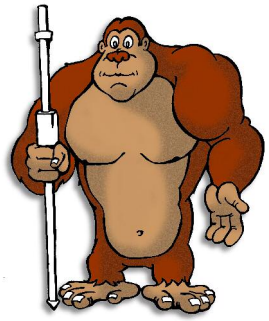
Evaluation Procedures
Assess Pavement Condition





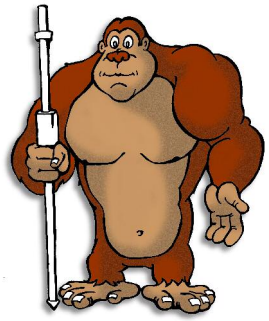
Pavement Condition Index Threefold Purpose

- **Provide information on apparent structural integrity, condition, and projected performance**
- **Impact the allowable gross loads**
  - **If 'poor' or below, PCI≤ 40, reduce structural capacity 25%**
- **Serves as baseline to assess damage caused by operations**
  - **Helps determine costs or liabilities associated with aircraft deployments**



Pavement Condition Index References

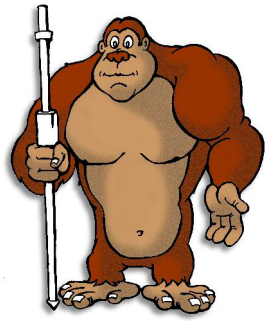
- **ASTM D5340-98, *Standard Test Method for Airport Pavement Condition Index Surveys***
- **UFC 3-270-5, *Paver, Concrete Surfaced Airfields Pavement Condition Index (PCI)***
- **UFC 3-270-6, *Paver, Asphalt Surfaced Airfields Pavement Condition Index (PCI)***



Pavement Condition Index
Pavement Distress

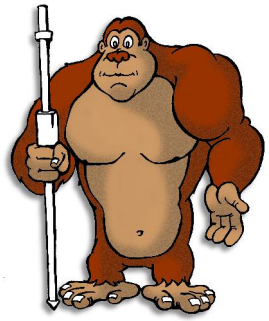
In conducting a PCI Survey, three distress parameters are considered:

- **Type of Pavement Distress**
- **Severity of Pavement Distress (How wide is the crack or how deteriorated is the surface ?)**
- **Density of Pavement Distress (How large is the distressed area ?)**



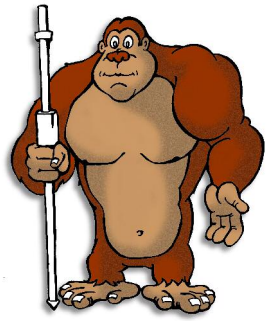
Pavement Condition Index Rating Definitions

Condition	Rating	Definition
Excellent	86 to 100	Pavement has minor or no distress and will require only routine Maintenance.
Very Good	71 to 85	Pavement has scattered low severity distresses which should need only routine maintenance.
Good	56 to 70	Pavement has a combination of low and medium severity distresses. Maintenance and repair needs will be routine to major in near term.
Fair	41 to 55	Pavement has low, medium, and high severity distresses which probably cause operational problems.
Poor	26 to 40	Pavement has predominantly medium and high severity distresses causing considerable maintenance and operational problems. Near term maintenance and repair needs will be intensive.
Very Poor	11 to 25	Pavement has mainly high severity distresses which cause operational restrictions. Repair needs are immediate.
Failed	0 to 10	Pavement deterioration has progressed to the point that safe aircraft operations are no longer possible. Complete reconstruction is required.



Pavement Condition Index
2004 Rating Scale

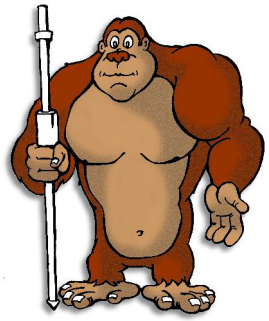
Existing		Rating	New (2004 Evals)	
Dark Green or Blue	Excellent	86 – 100	Green	Good
Green	Very Good	71 – 85	Bright Green	Satisfactory
Light Green or Cyan	Good	56 – 70	Yellow	Fair
Yellow	Fair	41 – 55	Rose	Poor
Magenta	Poor	26 – 40	Red	Very Poor
Red	Very Poor	11 – 25	Dark Red	Serious
Black	Failed	0 - 10	Light Gray	Failed



Pavement Condition Index
Pavement Distresses

Flexible Pavement
Structural Distresses

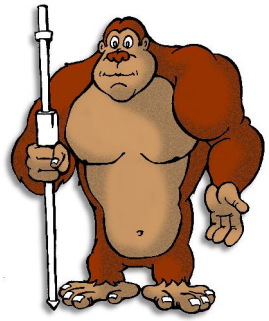
- **Alligator or Fatigue cracking**
- **Corrugation**
- **Depression**
- **Rutting**
- **Slippage cracking**



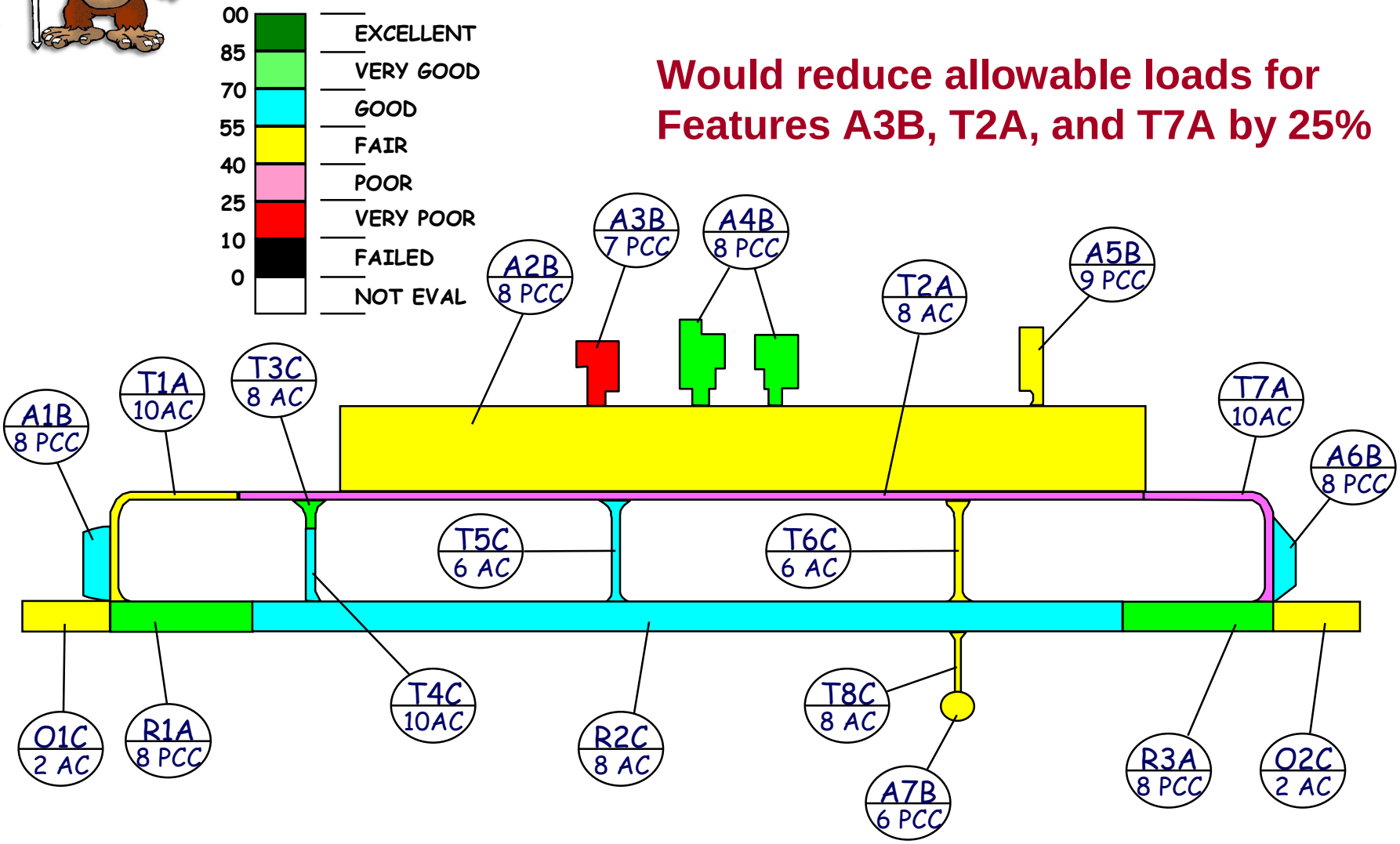
Pavement Condition Index
Pavement Distresses

Rigid Pavement Structural Distresses

- **Blow-up**
- **Corner Break**
- **Longitudinal, Transverse and Diagonal cracking**
- **Pumping**
- **Settlement or Faulting**
- **Shattered Slab / Intersecting cracks**



Pavement Condition Index
Airfield Map Depicting PCI



Pavement Condition Index
Semi-prepared Airfields

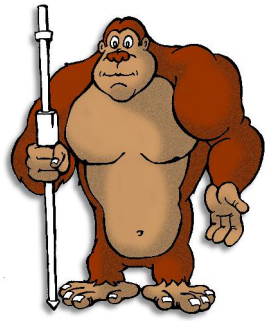
Landing Zone Suitability

in terms of…

Semi-prepared Airfield Condition Index

Provides guidance on:

- How to measure surface distresses
- How to rate suitability of airfield based upon severity of distresses

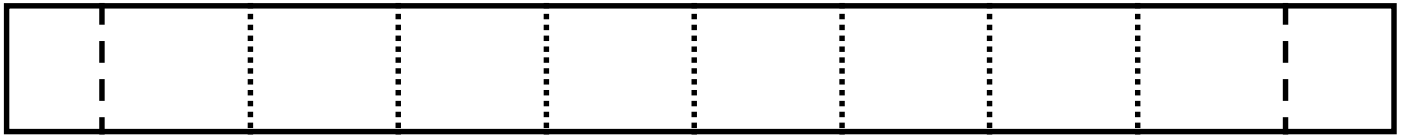


Pavement Condition Index
Semi-prepared Airfields

Runway Layout

500’ Sections (Coincide with Markers)

OVERRUN



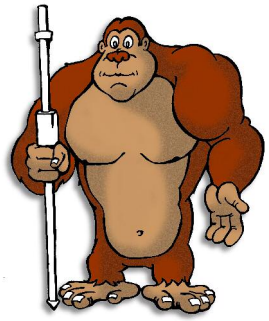
OVERRUN

Distress Locations

By Section

Distress Types

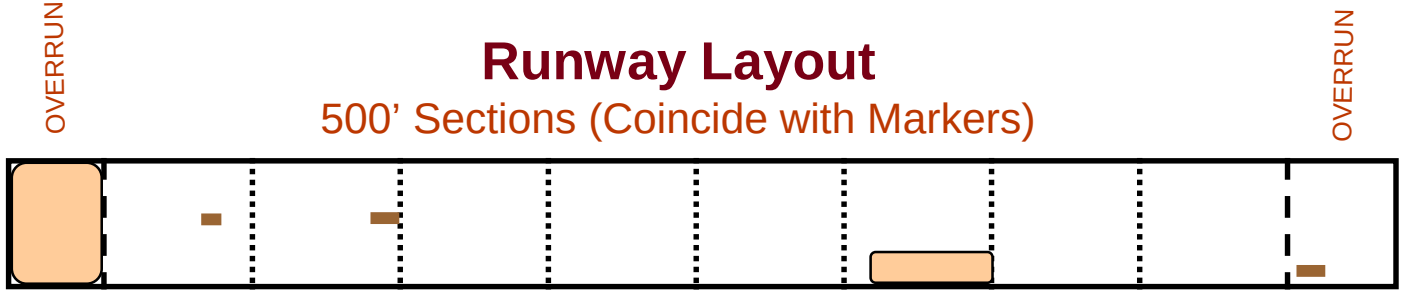
91 Potholes										
92 Ruts										
93 Loose Aggregate										
94 Dust										
95 Rolling Resistant Mat.										
96 Jet Blast Erosion										
97 Stabilized Layer Failure										



Pavement Condition Index
Semi-prepared Airfields

Runway Layout

500’ Sections (Coincide with Markers)

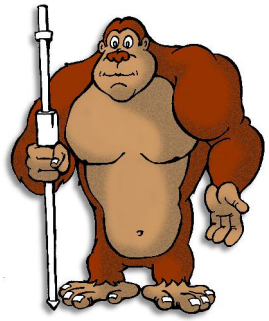


Distress Locations

By Section

Distress Types

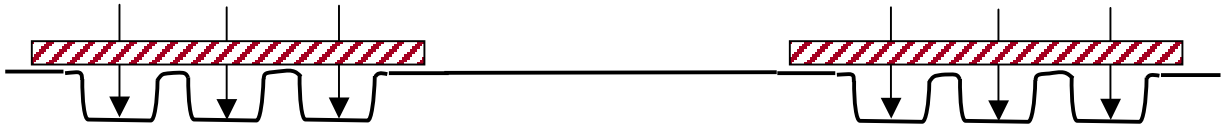
91 Potholes										
92 Ruts		30’L x 3”Deep	50’L x 5”Deep							15’L x 4”Deep
93 Loose Aggregate							½” Dia, 400’ x 30’			
94 Dust										
95 Rolling Resistant Mat.			2”Deep in Rut area							
96 Jet Blast Erosion	3/4” Deep									
97 Stabilized Layer Failure										



Pavement Condition Index
Semi-prepared Airfields

Ruts

Rut Depth Measurements

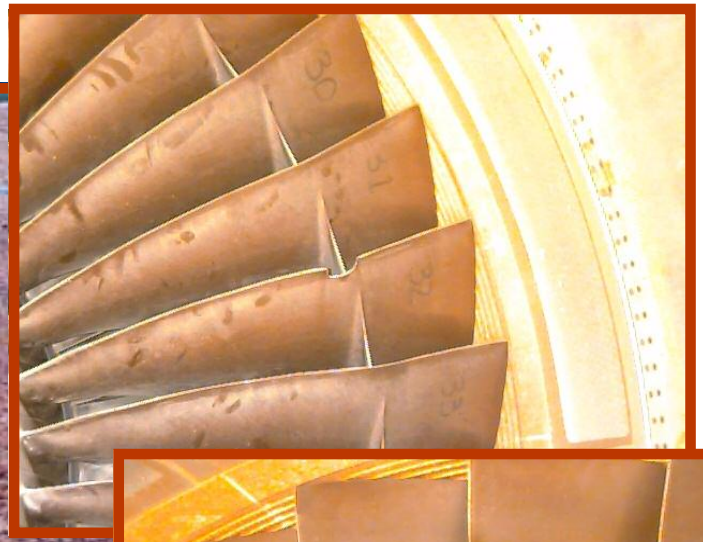


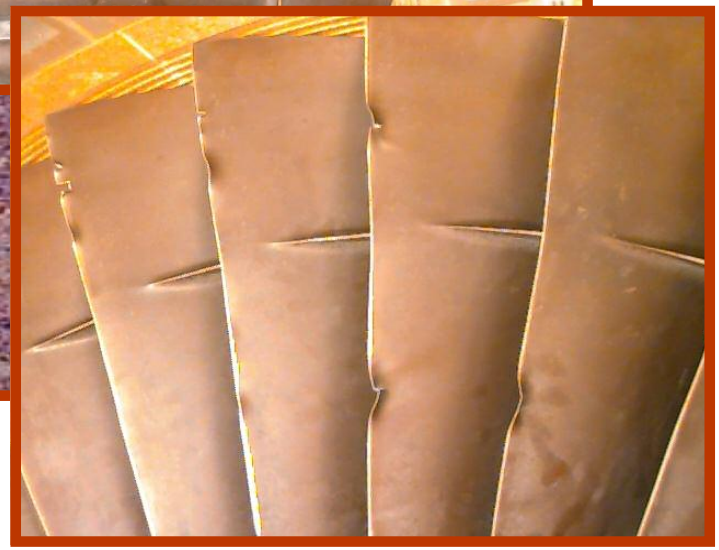
Location 1 Measurements		Location 2 Measurements		Location 3 Measurements		Location 4 Measurements	
1. ____	4. ____	1. ____	4. ____	1. ____	4. ____	1. ____	4. ____
2. ____	5. ____	2. ____	5. ____	2. ____	5. ____	2. ____	5. ____
3. ____	6. ____	3. ____	6. ____	3. ____	6. ____	3. ____	6. ____

Loc 1 Max= ____ Loc 2 Max= ____ Loc 3 Max= ____ Loc 4 Max= ____

Runway Maximum Rut Depth = _____

Pavement Condition Index
Semi-prepared Airfields

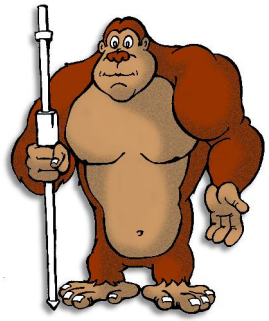




Loose Aggregate

Pavement Condition Index
Semi-prepared Airfields

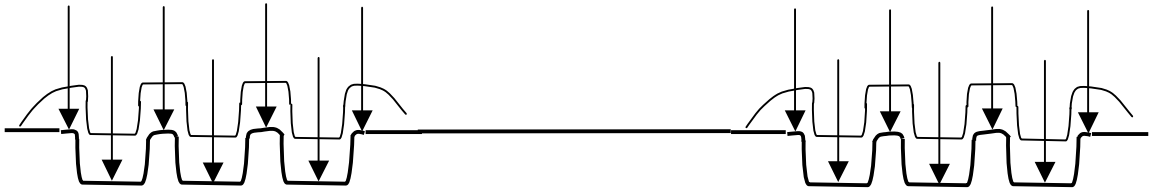
Dust



Pavement Condition Index
Semi-prepared Airfields

Rolling Resistant Material (Till)

Measure Thickness of RRM



Location 1 Measurements		Location 2 Measurements		Location 3 Measurements		Location 4 Measurements	
1. ____	8. ____	1. ____	8. ____	1. ____	8. ____	1. ____	8. ____
2. ____	9. ____	2. ____	9. ____	2. ____	9. ____	2. ____	9. ____
3. ____	10. ____	3. ____	10. ____	3. ____	10. ____	3. ____	10. ____
4. ____	11. ____	4. ____	11. ____	4. ____	11. ____	4. ____	11. ____
5. ____	12. ____	5. ____	12. ____	5. ____	12. ____	5. ____	12. ____
6. ____	13. ____	6. ____	13. ____	6. ____	13. ____	6. ____	13. ____
7. ____	14. ____	7. ____	14. ____	7. ____	14. ____	7. ____	14. ____

Loc 1 Avg= ____

Loc 2 Avg= ____

Loc 3 Avg= ____

Loc 4 Avg= ____

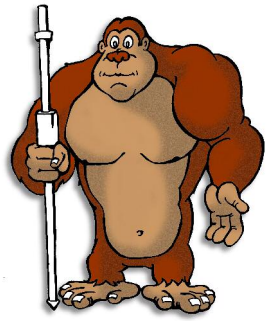
Runway RRM
Average Depth = _____

Pavement Condition Index
Semi-prepared Airfields

Jet Blast Erosion

Pavement Condition Index
Semi-prepared Airfields

Stabilized Layer Failure



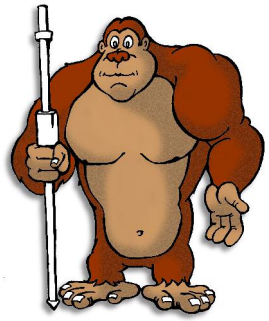
Pavement Condition Index
C-17 Semi-prepared Surfaces

Distress Severity Levels for C-17 Semi-prepared Surfaces

Distress Types	GREEN	AMBER	RED
91 Potholes	4” Deep and/or <15” Diameter	4” to 9” Deep and >15” Diameter	> 9” Deep and >15” Diameter
92 Ruts	Exist but < 4” Deep	4” to 9” Deep	>9” Deep
93 Loose Aggregate	Covers < 1/10 of section	Covers between 1/10 and 1/2 of section	Covers > 1/2 of section
94 Dust	Does not obstruct visibility	Partially obstructs visibility	Thick, obstructs visibility
95 Rolling Resistant Mat.	Exist but < 3.5” Deep	3.5” to 7.75” Deep	> 7.75” Deep
96 Jet Blast Erosion	Exist but < 1” Deep	1” to 3” Deep	> 3” Deep
97 Stabilized Layer Failure	Exist but < 1” Deep	1” to 2” Deep	> 2” Deep

Note: Potholes, ruts, and rolling resistant material are considered major distresses. Depending upon actual distress location, any of these distress types categorized as RED may cause overall airfield condition to be RED.

Training sites must meet green criteria, Contingency sites must meet yellow criteria



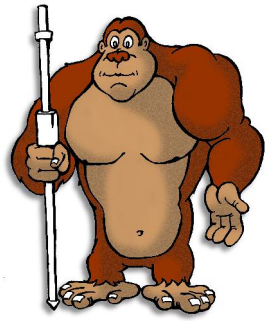
Pavement Condition Index
C-130 Semi-prepared Surfaces

Distress Severity Levels for C-130 Semi-prepared Surfaces

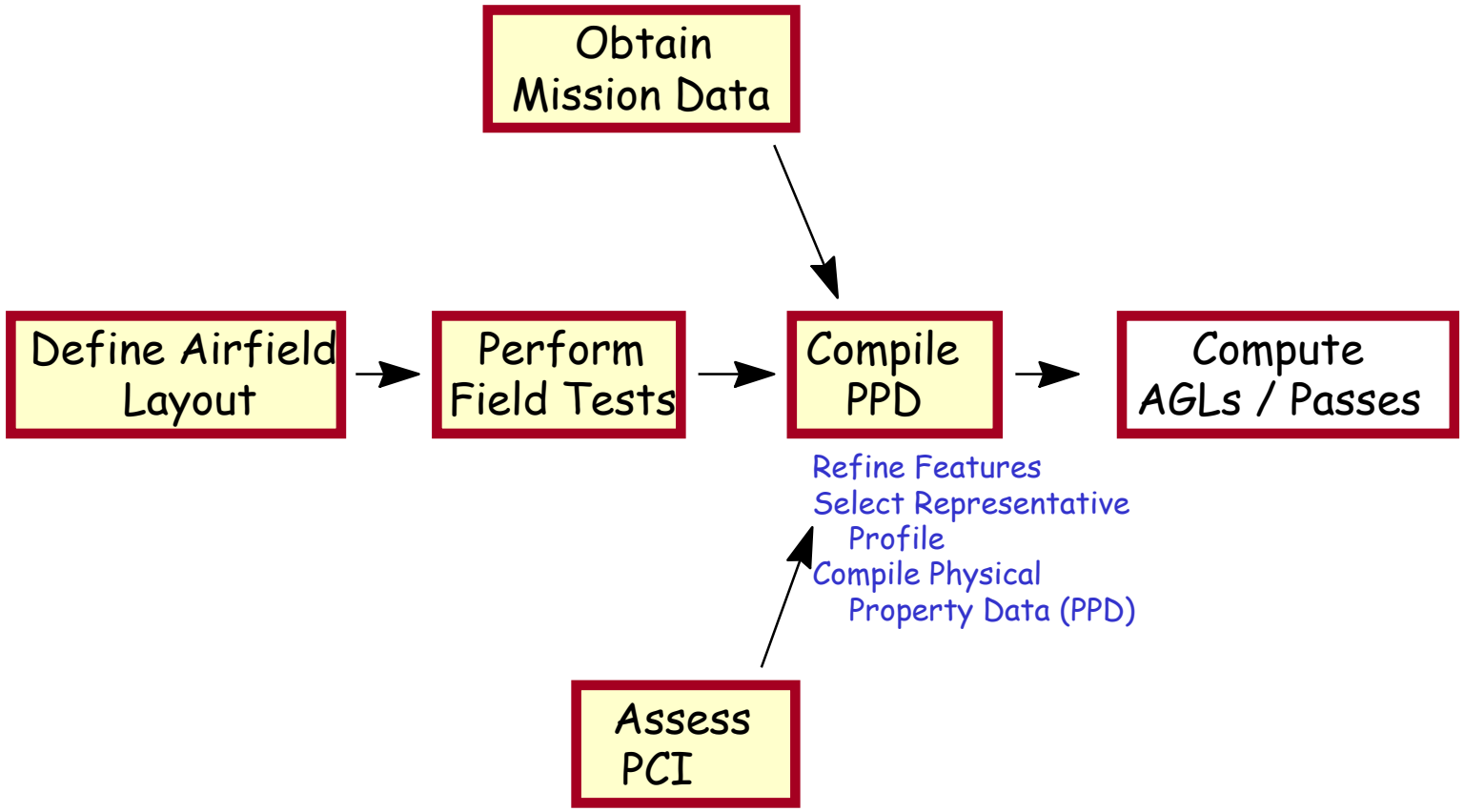
Distress Types	GREEN	AMBER	RED
91 Potholes	4” Deep and/or <15” Diameter	4” to 6” Deep and >15” Diameter	> 6” Deep and >15” Diameter
92 Ruts	Exist but < 3” Deep	3” to 6” Deep	>6” Deep
93 Loose Aggregate	Covers < 1/10 of section	Covers between 1/10 and 1/2 of section	Covers > 1/2 of section
94 Dust	Does not obstruct visibility	Partially obstructs visibility	Thick, obstructs visibility
95 Rolling Resistant Mat.	Exist but < 1” Deep	1” to 3” Deep	> 3” Deep
96 Jet Blast Erosion	Exist but < 1” Deep	1” to 3” Deep	> 3” Deep
97 Stabilized Layer Failure	Exist but < 1” Deep	1” to 2” Deep	> 2” Deep

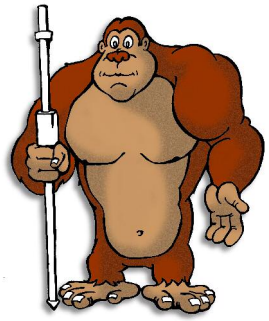
Note: Potholes, ruts, and rolling resistant material are considered major distresses. Depending upon actual distress location, any of these distress types categorized as RED may cause overall airfield condition to be RED.

Training sites must meet green criteria, Contingency sites must meet yellow criteria



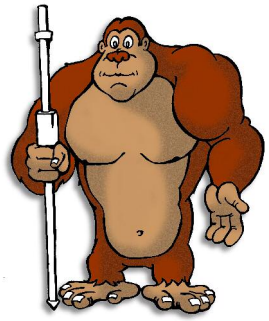
Evaluation Procedures
Compile PPD





Evaluation Procedures Compile PPD

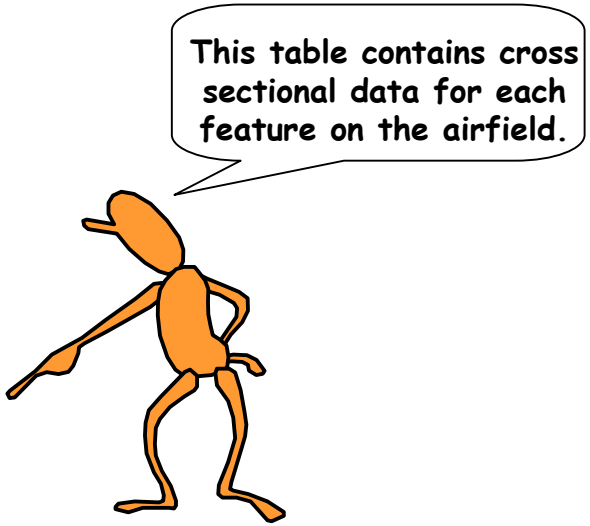
- Airfield Layout Updated Based upon:
  - Field Test Results
  - Aircraft Mission Data
  - Pavement Condition Assessment
- For Expedient Evaluations, Enter Each DCP on PPD
  - If more than one DCP on feature, weakest controls
- Group by Common Characteristics
- Establish Representative Profile for Each Feature
  - CBR Values Should Be a Low Average (85% of Average, but Never Lower than the Lowest Measured CBRs
- Compile Feature Characteristics into Summary of Physical Property Data (PPD)



Compile PPD Feature Data in Table Format

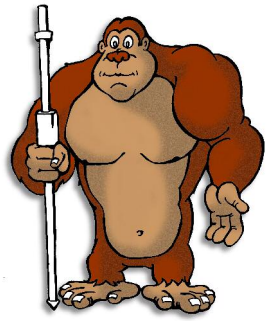
If evaluating flexible pavement, CBRs are recorded for soil strength

If evaluating rigid pavement, K-values are recorded for soil strength --- only one K value is entered for a given feature, the K-value for the controlling layer

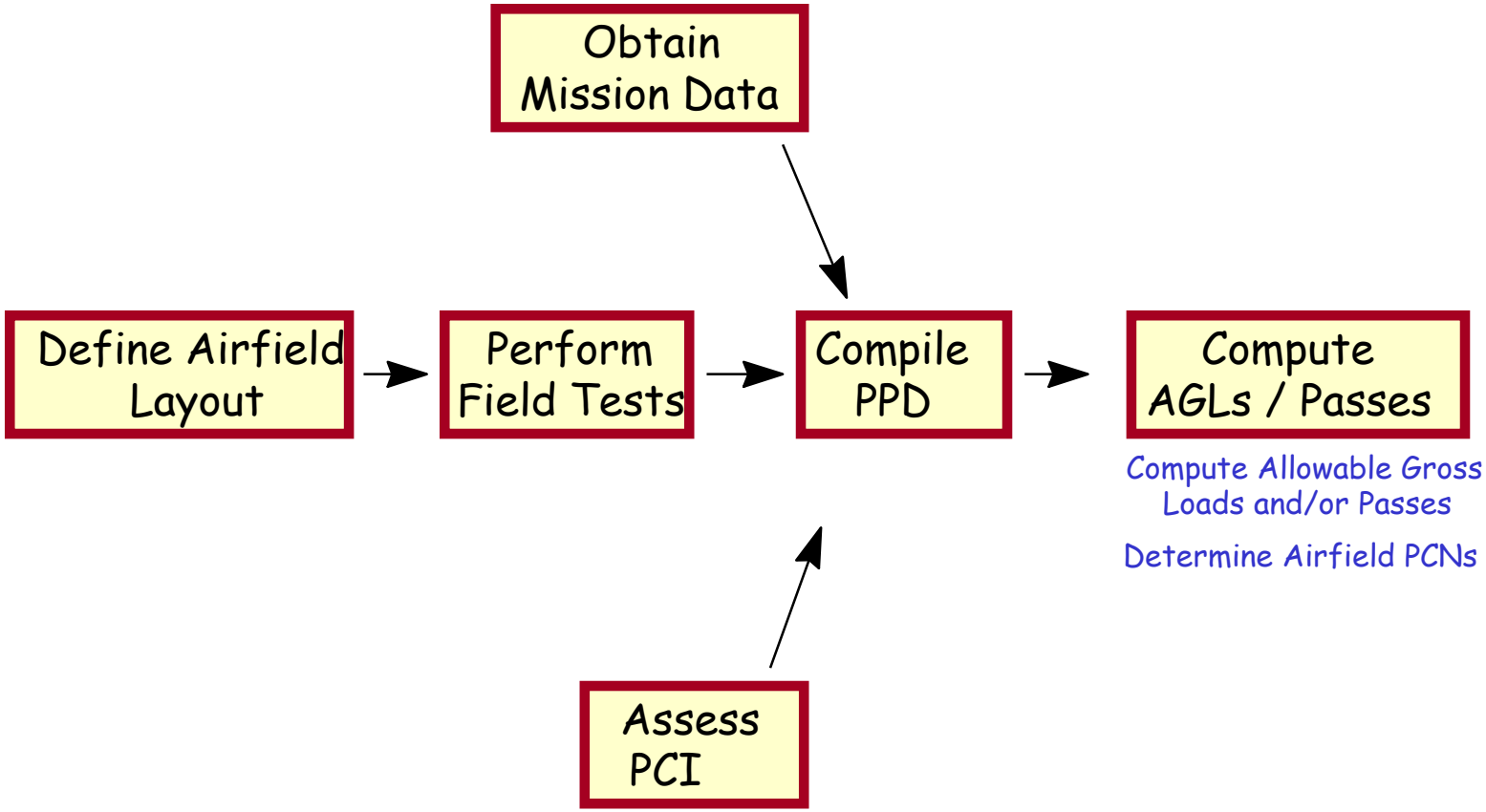


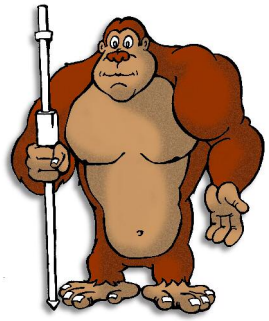
SUMMARY OF PHYSICAL PROPERTY DATA

Feature				Overlay			Pavement			Base			Subbase			Subgrade	
Feature Number	Identification	Area Sq Ft	Condition	Thick (in)	Descrip	Flex Strength	Thick (in)	Descrip	Flex Strength	Thick (in)	Descrip	K/CBR	Thick (in)	Descrip	K/CBR	Descrip	K/CBR
A01B	South Run-Up Apron	75,000	Excellent		---		8	PCC	750	8	GP	350		---		SM	
A02B	Main Ramp	3,000,000	Fair		---		8	PCC	700		---			---		SM	150
A03B	Hangar 3 Apron	45,000	Poor		---		7	PCC	600		---			---		SM	150
A04B	Hangar 2 Apron	100,625	V. Poor		---		8	PCC	700		---			---		SM	150
A05B	Hangar 1 Apron	56,250	Failed		---		9	PCC	550		---			---		SM	150



Evaluation Procedures
Compute AGLs / Passes

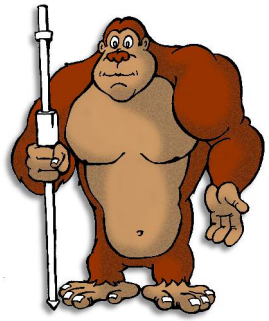




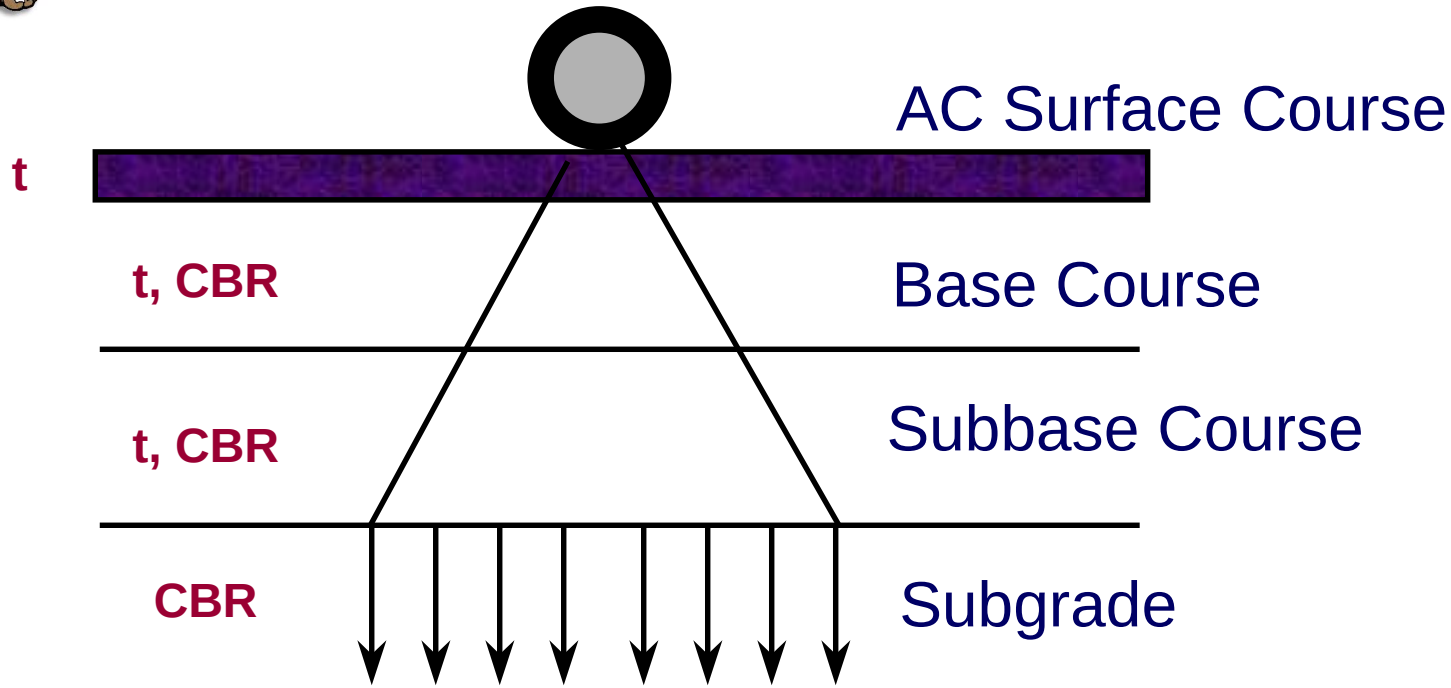
Compute AGLs / Passes Standardize Data Analysis

- **Flexible Pavements**
- **Rigid Pavements**
- **Semi-prepared Airfields**
- **Overlays/Composite Pavements**

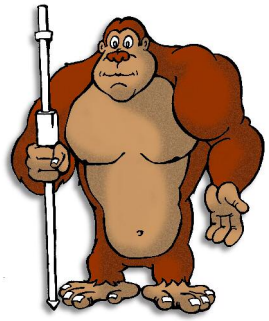
Compute manually and using WES developed PCASE software programs



Compute AGLs / Passes Flexible Pavement



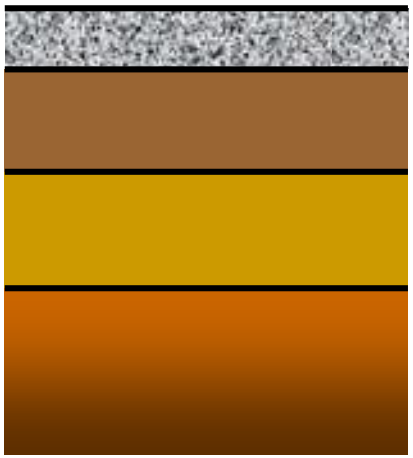
- Subsurface layers carry most of load
- Each layer must be strong enough to resist stresses from layer above it



Compute AGLs / Passes Flexible Pavement

Surface course
Asphalt:
Thickness
Condition
No strength parameter

Base Course
Type
Thickness
Strength
(CBR)



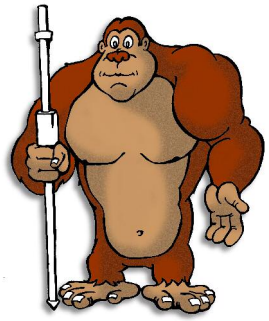
Subbase Course(s)
Type
Thickness
Strength
(CBR)

Subgrade
Type
Strength
(CBR)

Evaluate all layers in the section:

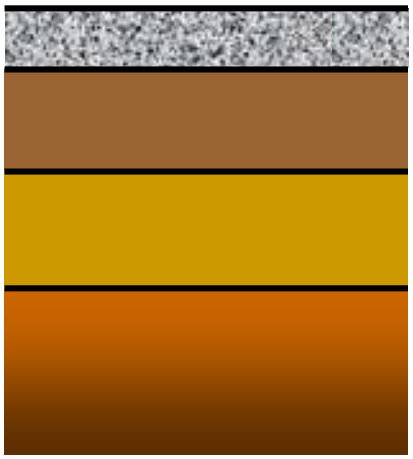
Evaluate strength of each layer and thickness of cover above it

Layer with lowest capability is the critical or controlling layer



Compute AGLs / Passes Flexible Pavement

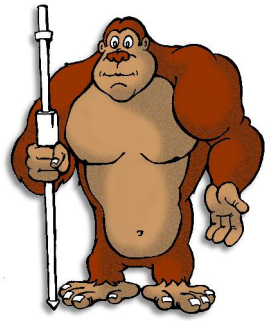
Example



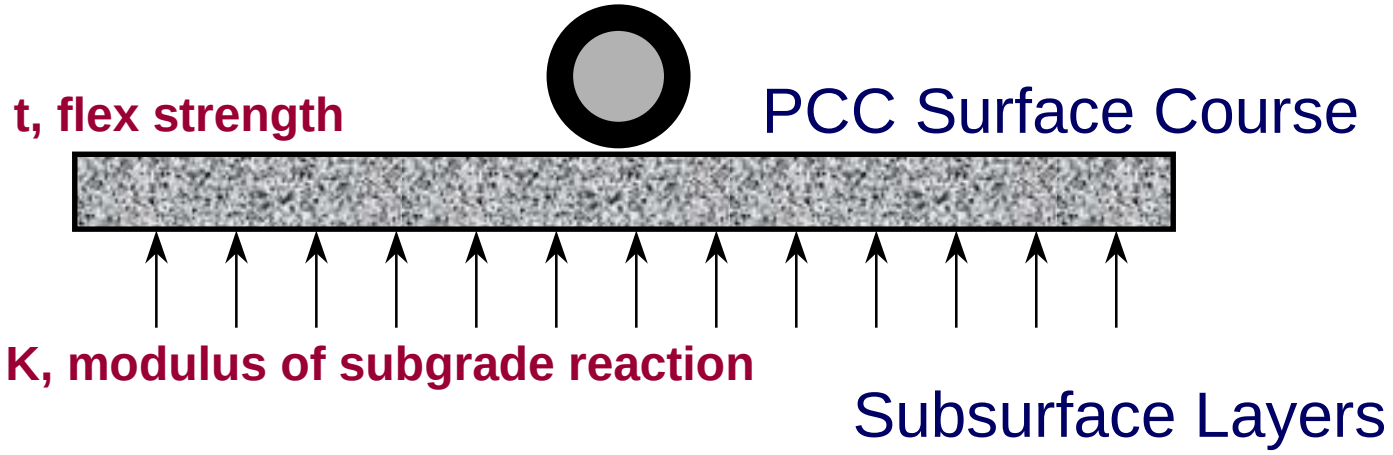
Evaluate each layer

1. Evaluate CBR 40 with 6” of cover
2. Evaluate CBR 15 with 18” of cover
3. Evaluate CBR 5 with 30”of cover

Layer with lowest capability controls the evaluation

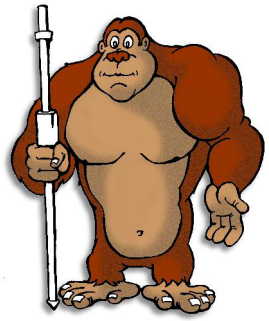


Compute AGLs / Passes Rigid Pavement



Pavement carries most of load. Slab is uniformly supported by soil during bending

One necessary input parameter is the Modulus of Subgrade Reaction (k), or the ratio of the applied load to the volume of displacement.



Compute AGLs / Passes Rigid Pavement

Surface course

Concrete:
- Thickness
- Condition
- Flexural strength in PSI

Base Course
- Type
- Thickness
- Strength

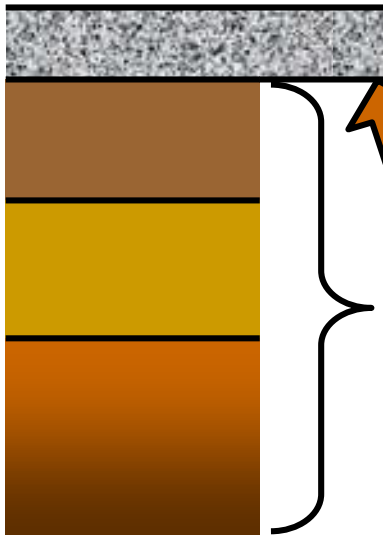
(CBR to K)

Subbase Course(s)
- Type
- Thickness
- Strength

(CBR to K to eff K)

Subgrade
- Type
- Strength

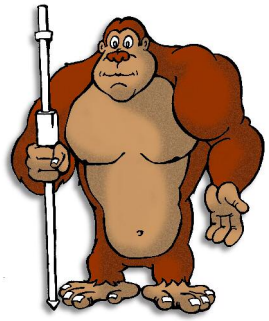
(CBR to K to eff K)



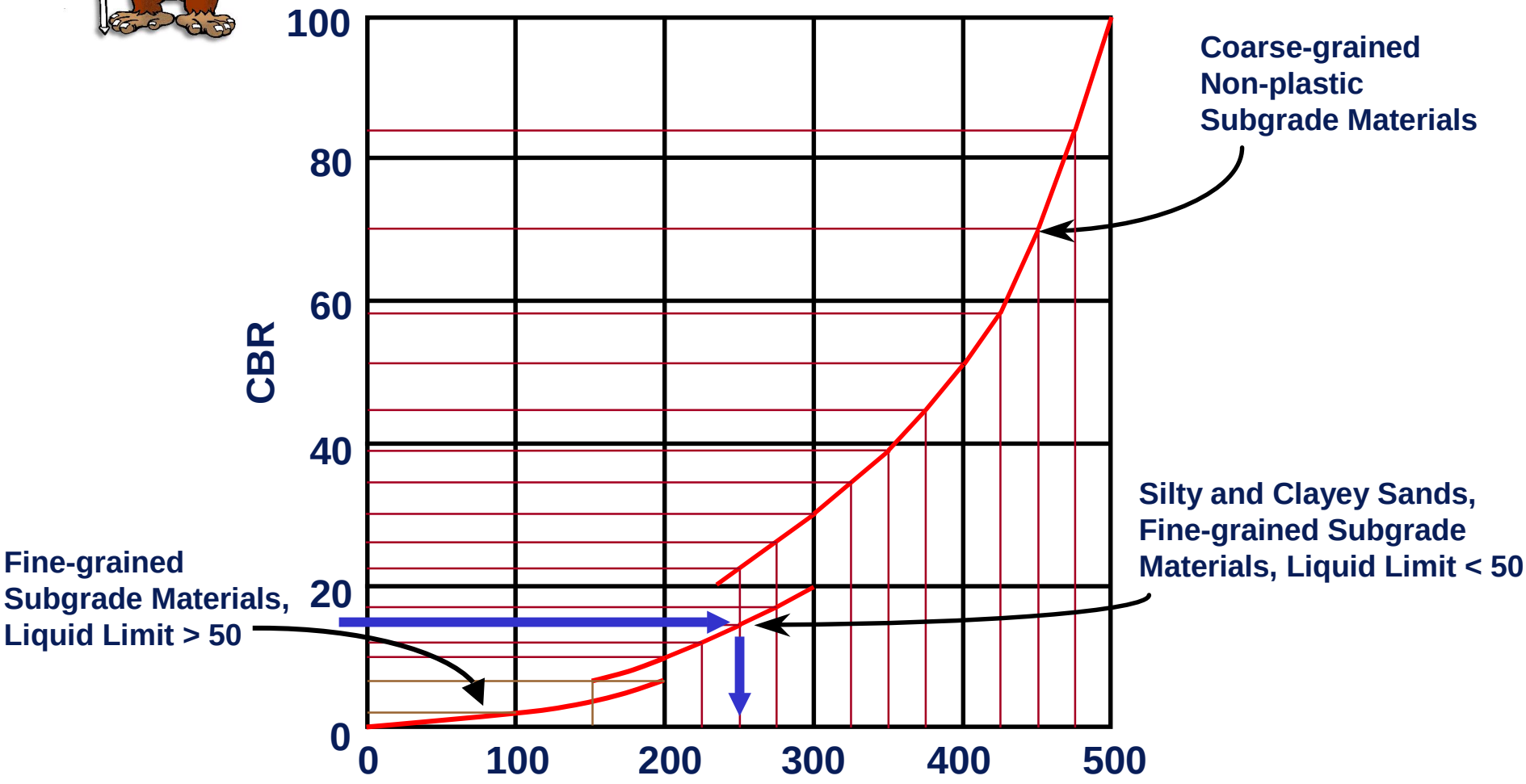
K-value at bottom of PCC slab
(lowest effective K)

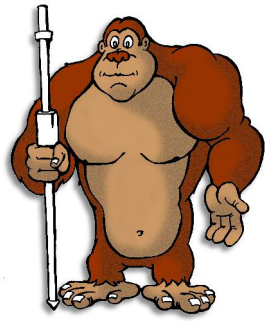
Evaluate all layers in the section:

Convert each layer CBR to a K-value
Convert each K-value to an effective K
Use lowest effective K-value to evaluate section

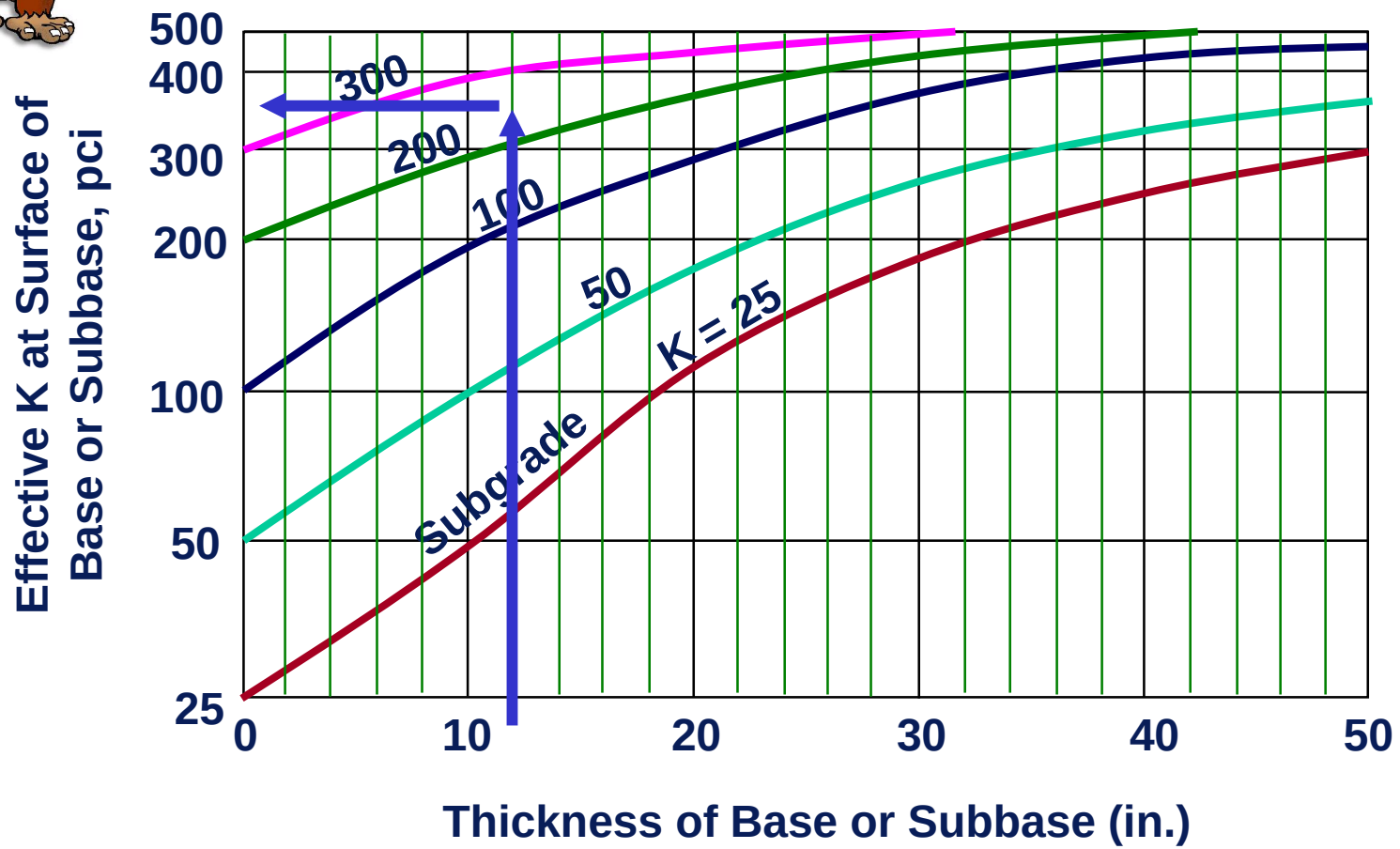


Compute AGLs / Passes
Rigid Pavement

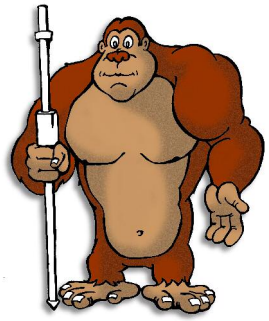




Compute AGLs / Passes Rigid Pavement

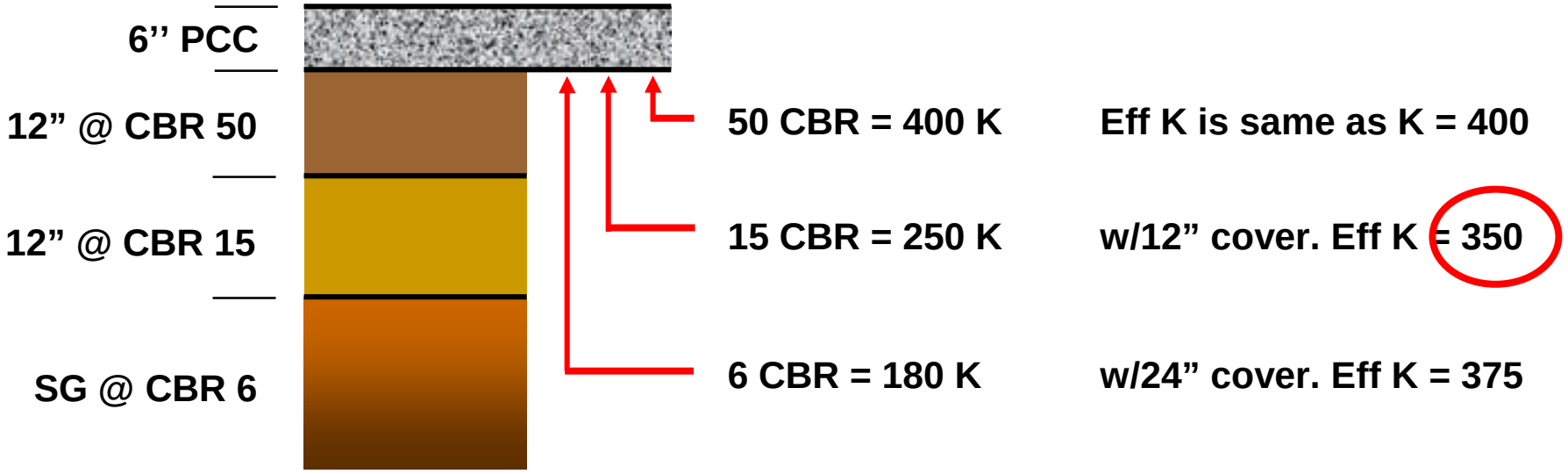


Effect of Base Course Thickness on Modulus of Soil Reaction K



Compute AGLs / Passes Rigid Pavement

Example



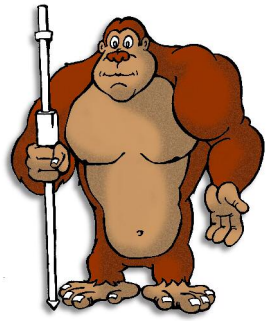
Evaluate all layers in the section:

Convert each layer CBR to a K-value

Convert each K-value to an effective K

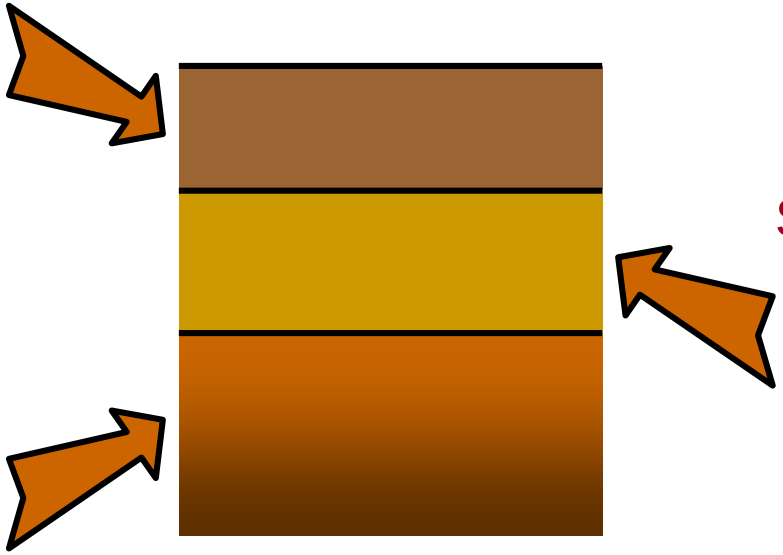
Use lowest effective K-value to evaluate section

Use 350 K to evaluate



Compute AGLs / Passes Semi-prepared Pavement

Surface Course
Type
Thickness
Strength
(CBR)

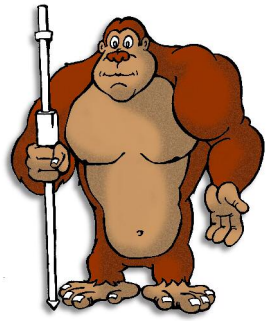


Subbase Course(s)
Type
Thickness
Strength
(CBR)

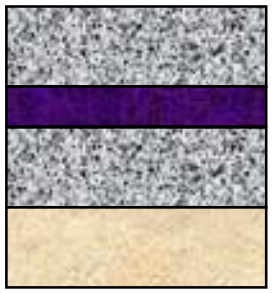
Subgrade
Type
Strength
(CBR)

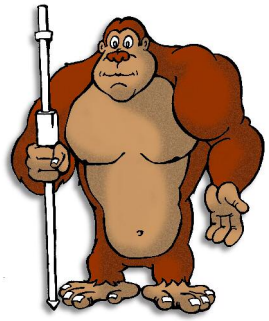
Evaluate all layers in the section:

Evaluate strength of surface course
Evaluate each subsurface layer and thickness of cover above it
Layer with lowest capability is the critical or controlling layer

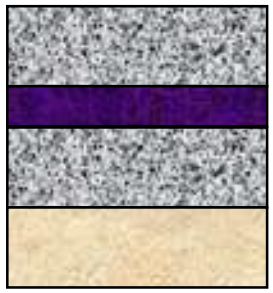


Compute AGLs / Passes Overlays/Composite Pavements





Compute AGLs / Passes Overlays/Composite Pavements

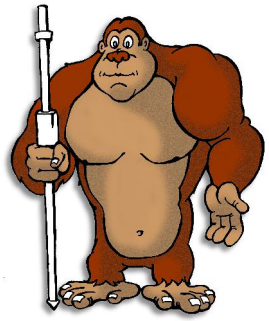


Using established formulas, determine the equivalent thickness of a single PCC slab that would have the same load-bearing capability of the overlay system

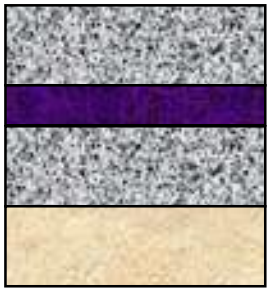
- **Use correction factor for thickness of the base pavement based upon its condition, assume based upon purpose of overlay**

Evaluate as rigid pavement

- **Determine the AGLs/passes using the new equivalent thickness single PCC slab**



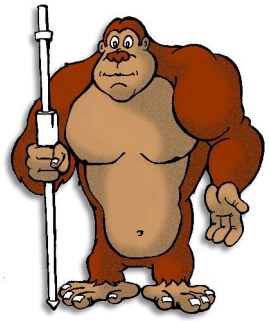
Compute AGLs / Passes Overlays/Composite Pavements



Evaluate as rigid pavement

Determine the AGLs/passes using:

- **Thickness and flexural strength of PCC Overlay**
- **Non-rigid bond breaker and base pavement are assumed to be a high strength base course, the assigned K-value is determined by the type bond breaker and the distresses evident on the pavement surface**



Compute AGLs / Passes Overlays/Composite Pavements

AC, Overlay

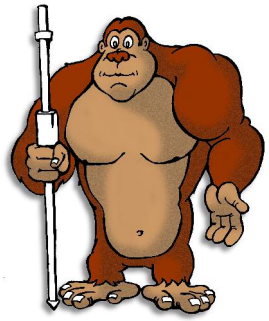
AC, Base pavement

Base Course

Evaluate as flexible pavement

Determine the AGLs/passes using:

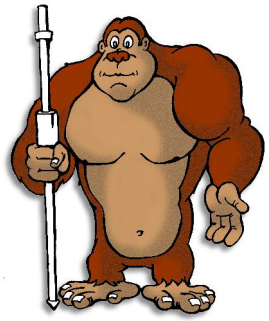
- **Combined thickness of all AC layers**



Compute AGLs / Passes Overlays/Composite Pavements

1. Evaluate as rigid pavement
   - Using equivalent thickness of PCC
     - •Factor for thickness of PCC is based upon reflective cracks on surface of AC
     - •Factor is used to control level of allowed PCC failure
2. Evaluate as flexible pavement
   - Use thickness of AC overlay
   - Consider PCC as a high strength (100 CBR) base course

The method that produces the higher AGLs/passes is reported



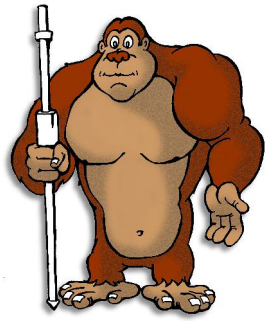
Compute AGLs / Passes Overlays/Composite Pavements

$$h_E = \sqrt[1.4]{(h_e)^{1.4} + \left(\sqrt[3]{\frac{E_s}{E_c}}\, h_s\right)^{1.4}}$$

h_E = Equivalent Thickness of Combined Base Slab and Stabilized Base
h_e = Thickness of Base Slab
h_s = Thickness of Stabilized Base
E_c = Modulus of Elasticity of Base Slab
E_s = Flexure Modulus of Stabilized Layer

Evaluate as rigid pavement

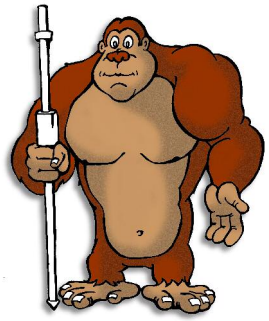
- **Determine an equivalent thickness of PCC that would represent the combined PCC and stabilized base layers**
- **Modulus of Elasticity for stabilized is determined based upon its compressive strength**



Compute AGLs / Passes ACN/PCN System

Standard method recognized by the International Civil Aviation Organization (ICAO) of reporting airfield capability

- **ACN/PCN System Simplifies Aircraft Management**
- **Aircraft Classification Number (ACN)**
  - **Relative damage to pavement**
  - **Based on aircraft type, weight, and type of subgrade**
  - **In terms of a standard single-wheel load**
- **Pavement Classification Number (PCN)**
  - **Strength to failure**
  - **Based on aircraft type, pass level, and subgrade strength**
  - **In terms of a standard single-wheel load**
- **ACN/PCN < 1 O.K.**
- **ACN/PCN > 1 other considerations**



Compute AGLs / Passes ACN/PCN Code

Pavement Type

R = rigid, concrete

F = flexible, asphalt

Evaluation Method

T = technical

U = type of using aircraft

30 / R / A / W / T

Subgrade Strength

A = high, ≥ 13 CBR, ≥ 400 K

B = med, ≥ 8 CBR, ≥ 200 K

C = low, ≥ 4 CBR, ≥ 100 K

D = ultra low, < 4 CBR, < 100 K

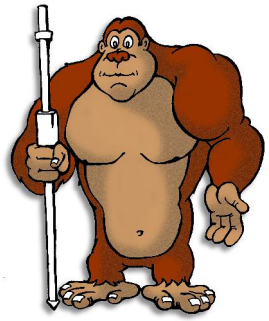
Tire Pressure

W = high, no limit

X = med, ≤ 217 psi

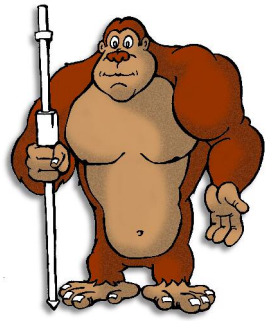
Y = low, ≤ 145 psi

Z = very low, ≤ 73 psi



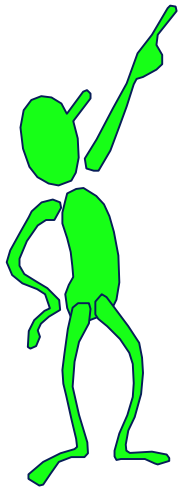
Compute AGLs / Passes Report PCNs for Each Feature

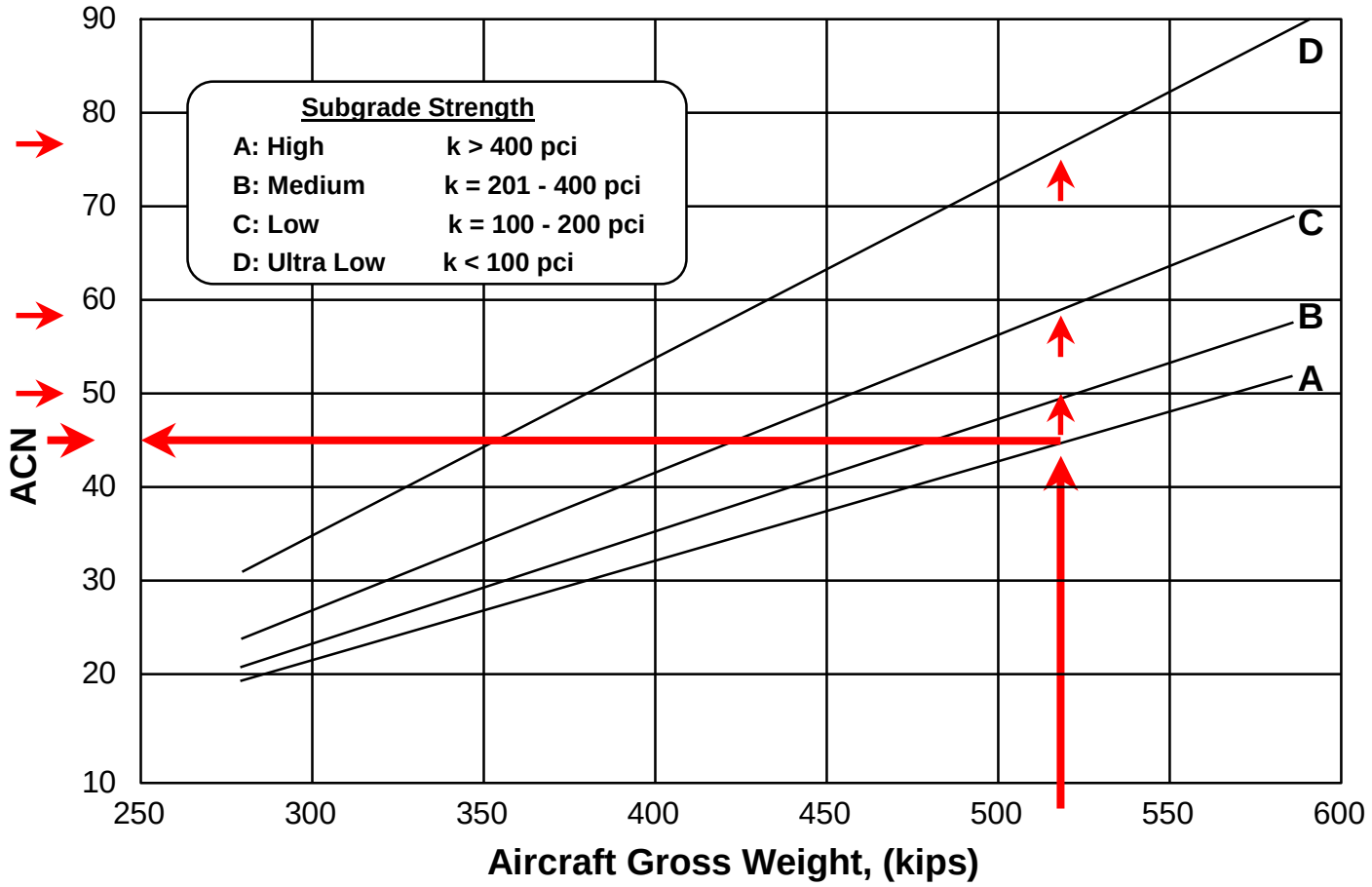
- PCN is now determined based upon C-17 aircraft, 50,000 passes. Previously based upon C-141 aircraft, 50,000 passes.
- PCN reported by HQ AFCESA to NGA to be reported in the Flight Information Publication (FLIP) is the PCN of the weakest feature located in the center 75' wide keel section of the runway, threshold to threshold.
- Sources for ACNs
  - Aircraft Manufacturers
  - AFCESA Aircraft Characteristics and Eval Reports
  - USARMY ETL 1110-3-394 (dtd 1991)
  - COE WES computer program



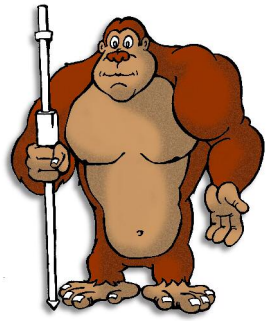
Compute AGLs / Passes Determining the PCN

C-17 Aircraft, Flexible Pavement





Enter at 520 Kips, Vertical to subgrade of A, PCN = 45/F/A/W/T



ACN/PCN Ratios
USAF Recommendations

ACN/PCN Ratio	Recommendation
< 1.0	Unlimited Passes
1.0 - 1.1	Continue Operations, but watch for distresses
1.1 - 1.4	Limited to 10 Passes, inspect after each operation
> 1.4	Emergencies Only, if concern is to minimize pavement damage

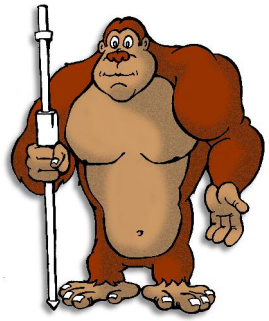
For expedient evaluations and for those sustainment evaluations where concern is to land aircraft in lieu of protecting the pavement, do not restrict operations just because ACN/PCN ratio exceeds 1.1.

Do not exceed ACN/PCN Ratio of 1.0 if:

Wet Season

Thaw Period

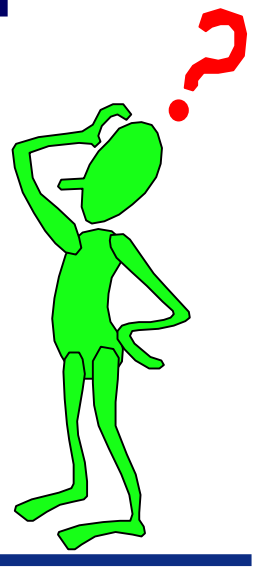
Excessive Structural Distresses

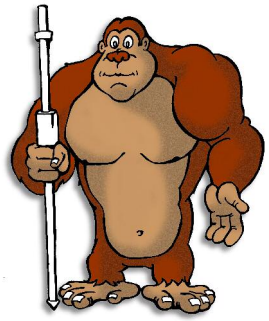


Compute AGLs / Passes ACN/PCN System

CAUTION

- **Not all PCNs are based upon the C-17 aircraft, at 50,000 passes.**
- **Army uses traffic mix peculiar to the airfield.**
- **Although ACN method is standard, each nation chooses the type aircraft and characteristics used to compute it. Many PCNs are based upon using aircraft.**
- **Must know source of PCN, aircraft characteristics and pass levels used to compute it.**

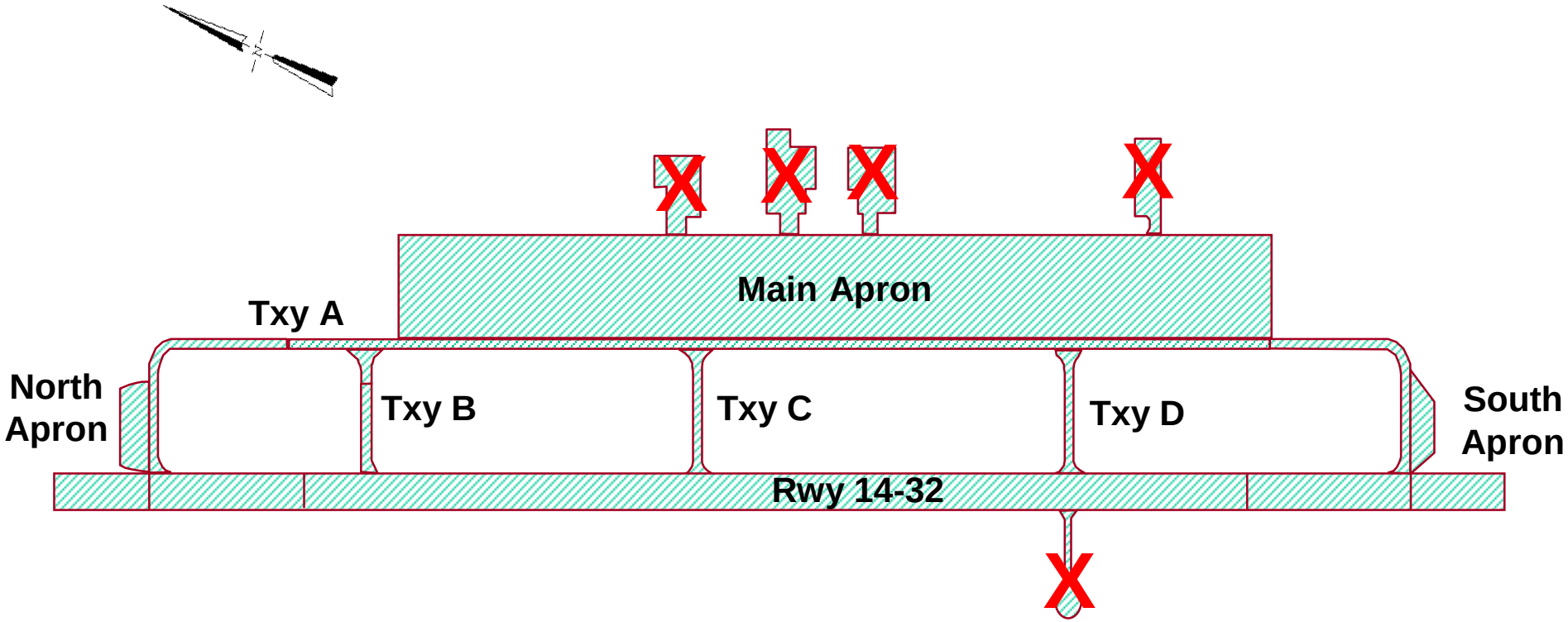


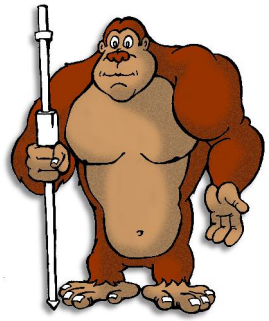


ACN/PCN Ratios
Contingency Applications

Potential Airfield

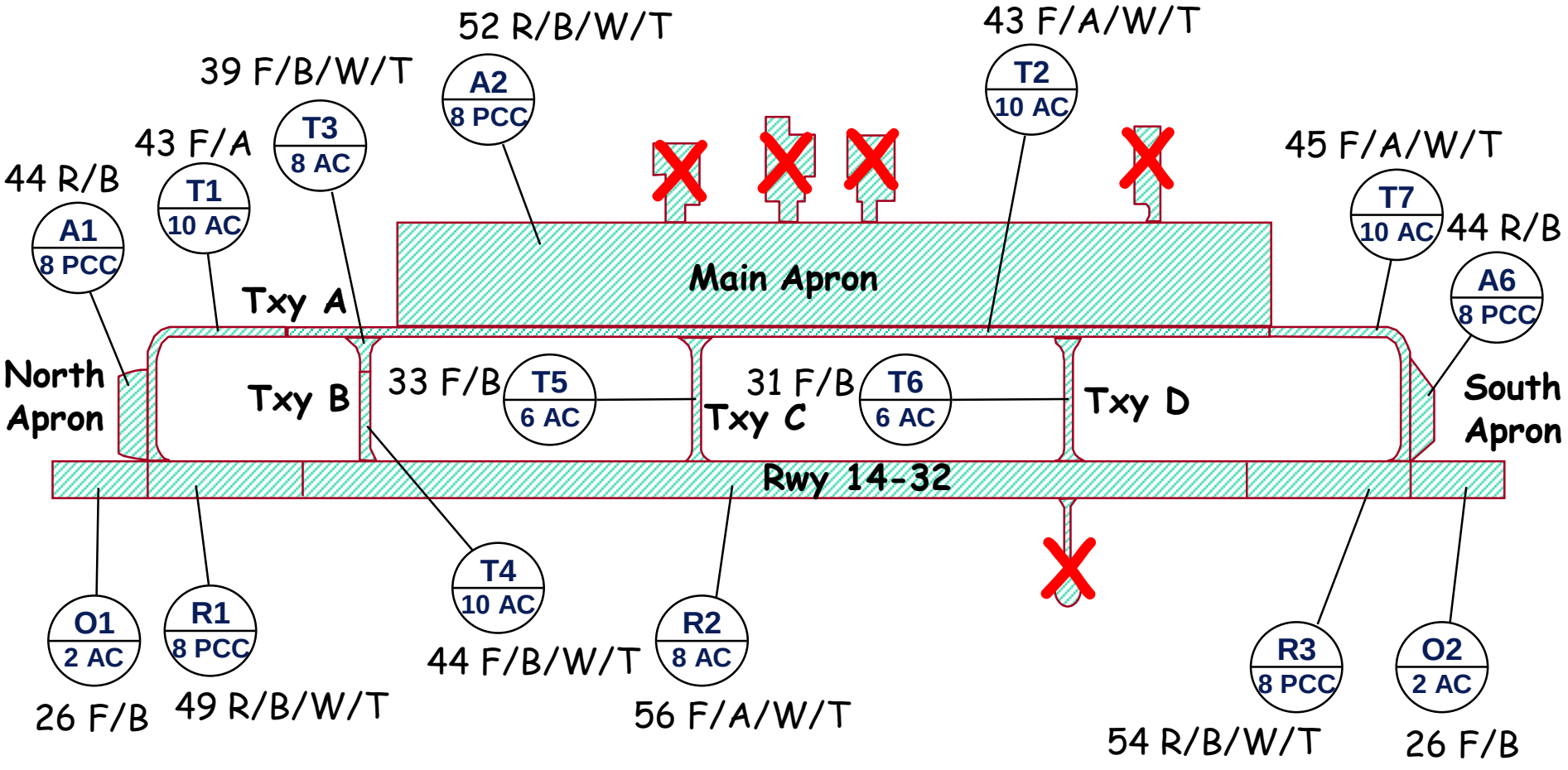
Evaluate for C-130 and limited C-17 operations

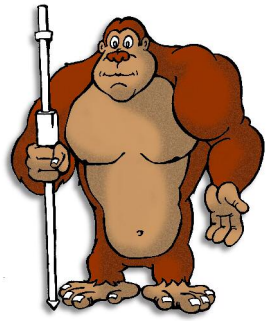




ACN/PCN Ratios
Contingency Applications

Determine allowable passes for C-130 and C-17 and establish PCNs for each feature





ACN/PCN Ratios
Contingency Applications

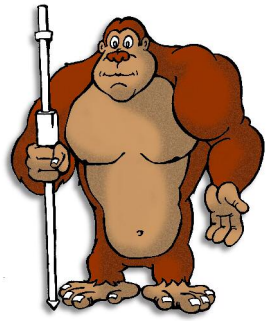
Controlling PCNs			
Rwy 14-32	49 R/B/W/T	Txy D	31 F/B/W/T
Txy A	43 F/A/W/T	Main Apron	52 R/B/W/T
Txy B	39 F/B/W/T	N/S Aprons	44 R/B/W/T
Txy C	33 F/B/W/T	Overruns	26 F/B/W/T

Can determine structural capability of airfield to support any other aircraft by comparing the aircraft ACNs to the PCNs of the airfield

ACN/PCN

Air Force Recommendations

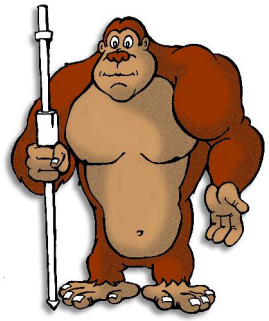
ACN/PCN Ratio		
< 1.1		Fully capable
1.1 – 1.4		Limited operations
> 1.4		Emergency operations



ACN/PCN Ratios
Contingency Applications

Aircraft	Rigid Pavement				Flexible Pavement			
	Subgrade Strength				Subgrade Strength			
	A	B	C	D	A	B	C	D
Fighters								
F-14B/D	30	30	30	30	28	28	28	28
F-15C/E	28/37	28/37	28/37	28/37	26/35	25/33	24/33	23/33
F-16C/CJ/CG	17	17	17	17	16	16	16	16
F/A-18A/C	25	25	25	25	25	25	25	25
F-117A	25	25	24	24	19	19	18	18
OA/A-10	21	21	21	21	20	20	20	20
EA-6B	26	26	26	26	26	25	25	24
AV-8B	9	9	11	11	11	12	14	16
Bombers								
B-1B	67	80	93	102	69	79	97	117
B-2A	44	52	61	67	45	50	62	78
B-52H	95	108	119	127	76	82	92	110
Heavy								
C-5 (all)	29	29	29	29	36	40	49	67
C-17A	49	49	49	65	52	57	69	90
C-130 (all)	34	37	41	43	30	34	37	43
AC-130	34	37	41	43	30	34	37	43
EC-130E	34	37	41	43	30	34	37	43
EC-130H	34	37	41	43	30	34	37	43

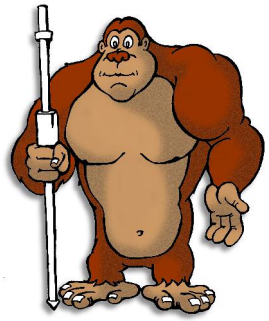
Airfield Structural Suitability: Aircraft ACNs



ACN/PCN Ratios
Contingency Applications

Aircraft	Rigid Pavement				Flexible Pavement			
	Subgrade Strength				Subgrade Strength			
	A	B	C	D	A	B	C	D
Heavy (cont.)								
EC-130H	34	37	41	43	30	34	37	43
MC-130E	33	37	40	42	30	33	36	42
C-141 (all)	46	55	64	71	47	54	66	81
KC-10A	45	55	67	77	56	61	74	101
KC-135R	31	38	46	52	36	40	49	63
KC-130F/R	34	37	41	43	30	34	37	43
RC-135V	34	41	50	56	34	41	49	56
E-2C	25	25	25	25	23	23	23	23
EP-3E	45	47	49	50	39	42	46	48
P-3B/C	40	43	44	45	35	38	42	44
S-3B	21	21	21	21	20	20	20	20
IL-76T	28	33	30	35	24	27	34	45
IL-76D/MD	34	37	35	40	29	32	40	53
IL-76MF	41	41	40	46	33	38	46	61
AN-124	34	48	64	79	48	56	70	92
767-200ER	43	52	62	70	48	53	65	86
L-1011-500	49	59	71	82	59	64	77	104

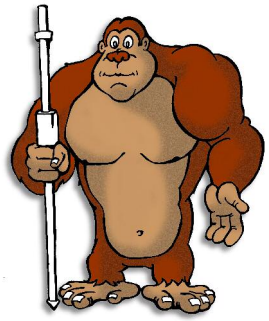
Airfield Structural Suitability: Aircraft ACNs



ACN/PCN Ratios
Contingency Applications

Aircraft	Rigid Pavement				Flexible Pavement			
	Subgrade Strength				Subgrade Strength			
	A	B	C	D	A	B	C	D
Other								
U-2S	21	21	21	21	10	10	10	10
C-21A	4	4	4	4	4	4	5	5
RC-12N	4	4	4	4	3	4	4	5
C-20G	24	25	25	26	18	20	21	22
C-2A	28	28	28	28	26	26	26	26
Predator	3	3	3	3	3	3	3	3
Rotary Wing								
UH-60A	6	6	6	6	6	6	6	6
UH-3H								
C/MH-53E/M	17	18	19	19	15	16	17	18
HH-60G/H	7	7	7	7	7	7	7	7
AH-64A	6	6	6	6	6	6	7	7
SH-60F	7	7	7	7	7	7	7	7
C/HH-46D/E	6	6	6	6	5	5	5	5
A/UH-1N/W								

Airfield Structural Suitability: Aircraft ACNs



ACN/PCN Ratios
Contingency Applications

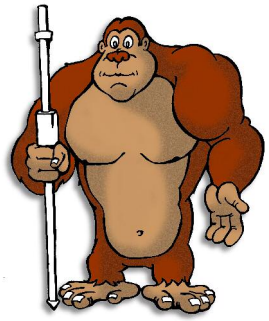
Compare Rwy PCN to aircraft ACN given for correct pavement type and subgrade strength

Aircraft	Rigid Pavement				Flexible Pavement			
	Subgrade Strength				Subgrade Strength			
	A	B	C	D	A	B	C	D
Fighters								
F-14B/D	30	30	30	30	28	28	28	28
F-15C/E	28/37	28/37	28/37	28/37	26/35	25/33	24/33	23/33
F-16C/CJ/CG	17	17	17	17	16	16	16	16
F/A-18A/C	25	25	25	25	25	25	25	25
F-117A	25	25	24	24	19	19	18	18
OA/A-10	21	21	21	21	20	20	20	20
EA-6B	26	26	26	26	26	25	25	24
AV-8B	9	9	11	11	11	12	14	16
Bombers								
B-1B	67	80	93	102	69	79	97	117
B-2A	44	52	61	67	45	50	62	78
B-52H	95	108	119	127	76	82	92	110
Heavy								
C-5 (all)	29	29	29	29	36	40	49	67
C-17A	49	49	49	65	52	57	69	90
C-130 (all)	34	37	41	43	30	34	37	43
AC-130	34	37	41	43	30	34	37	43
EC-130E	34	37	41	43	30	34	37	43
EC-130H	34	37	41	43	30	34	37	43

Rwy 14-32:
49 R/B/W/T

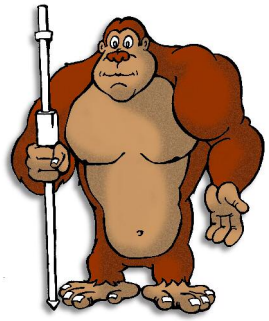
≥ 54 =

≥ 69 =



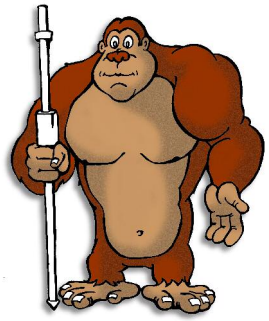
ACN/PCN Ratios
Contingency Applications

raft	RWY 14-32	Overruns	TXY A	TXY B	TXY C	TXY D	MAIN APRON	N/S APRONS
Fighters								
F-14B/D								
F-15C/E								
F-16C/CJ/CG								
F/A-18A/C								
F-117A								
OA/A-10								
EA-6B								
AV-8B								
Bombers								
B-1B								
B-2A								
B-52H								
Heavy								
C-5 (all)								
C-17A								
C-130 (all)								
AC-130								
EC-130E								
EC-130H								



ACN/PCN Ratios
Contingency Applications

raft	RWY 14-32	Overruns	TXY A	TXY B	TXY C	TXY D	MAIN APRON	N/S APRONS
Heavy (cont.)								
EC-130H								
MC-130E								
C-141 (all)								
KC-10A								
KC-135R								
KC-130F/R								
RC-135V								
E-2C								
EP-3E								
P-3B/C								
S-3B								
IL-76T								
IL-76D/MD								
IL-76MF								
AN-124								
767-200ER								
L-1011-500								

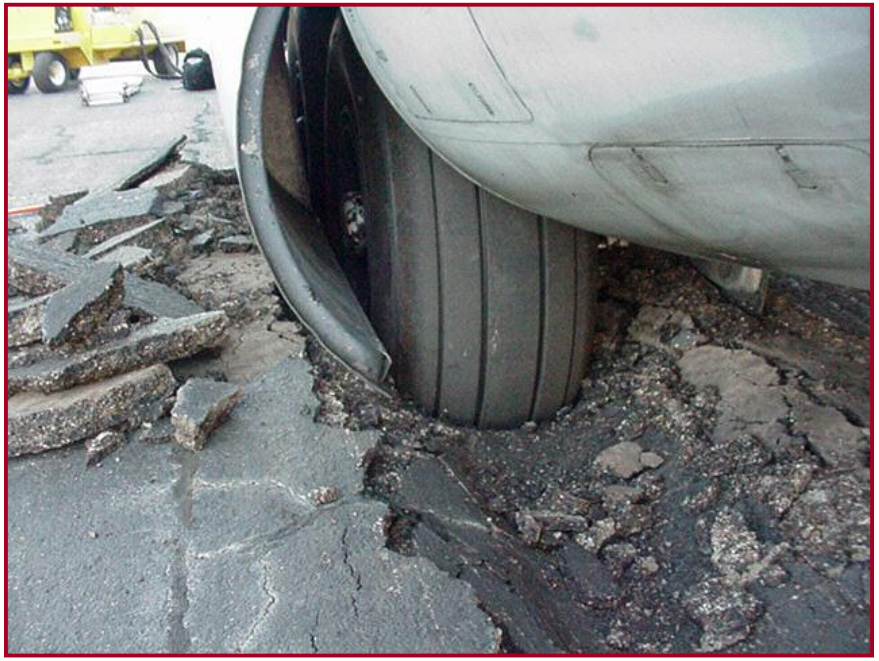


ACN/PCN Ratios
Contingency Applications

Determine structural suitability of each area of the airfield for potential mission aircraft

Aircraft	RWY 14-32	Overruns	TXY A	TXY B	TXY C	TXY D	MAIN APRON	N/S APRONS
Others								
U-2S								
C-21A								
RC-12N								
C-20G								
C-2A								
Predator								
Rotary Wing								
UH-60A								
UH-3H								
C/MH-53E/M								
HH-60G/H								
AH-64A								
SH-60F								
C/HH-46D/E								
A/UH-1N/W								

Contingency Airfield Evaluation



Why ?

Contingency Airfield Evaluation

Questions ?